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EXPERIMENTS *and* OBSERVATIONS,
TO INVESTIGATE,
BY CHEMICAL ANALYSIS,
THE
MEDICINAL PROPERTIES
OF THE
MINERAL WATERS
OF
SPA AND AIX-LA-CHAPPELLE,
IN GERMANY;
AND OF THE
WATERS AND BOUE
NEAR
ST. AMAND, IN FRENCH FLANDERS.

By JOHN ASH, M.D.
Fellow of the Royal College of Phyſicians, of the Royal
Society, and of the Society of Antiquaries.

Tales ſunt Aquæ, qualis Terra per quam ſluunt.
PLIN.

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——BEhold! the glooms diſcloſe,
I ſee the fountains in their infant beds;
Deep, deep I hear them labouring to get free:
I ſee the leaning ſtrata——
——The layers then
Of mingled ores, of more retentive earths;
The gutter'd rocks, the mazy-running clefts,
That, while the riſing vapour they tranſmit,
Reſtrain its motion and forbid its waſte:
I ſee the rocky ſiphons ſtretch'd immenſe,
The mighty reſervoirs of harden'd chalk
Or ſtiff compacted clay, capacious form'd:
O'erflowing thence, the congregated ſtores,
The chryſtal treaſures of the liquid world,
Through the ſtirr'd ſands a bubbling paſſage burſt,
And welling out, around the middle ſteep,
Or from the bottom of the boſom'd hills
In pure effuſion flow.——
But who their virtues can declare? who pierce,
With viſion pure, into theſe ſecret ſtores
Of health, and life, and joy?

THOMSON.

E R R A T A.

Page 49. line 1. for *in* read *is.*
53. 13. for *Thirmal's* read *thermal.*
61. 10. for *laſſene* read *laſſone.*
114. 6. for *acid* read *air.*
116. laſt, dele *was.*
137. 11. dele *as well as aerated.*
255. 20. and, in ſome other pages, for *ferruginous* read *ferrugineous.*

PREFACE.

WHEN I firſt formed a deſign of going to Spa, Aix-la-Chapelle, and the adjoining places, ſo filled with mineral waters, in the ſummer of the year 1787, I propoſed little more to myſelf than merely amuſement, and to collect, if poſſible, ſome better information of the nature of thoſe celebrated fountains, of which ſuch different and imperfect accounts have been given to the public, by a great variety of writers upon them: for, having been engaged for near forty years in a very extenſive range of medical practice, in a large and populous town, ſituated nearly in the central part of England, my attention had neceſſarily been directed to ſubjects of this kind; and I had frequently directed the uſe of ſome of theſe mineral waters to my patients, on the authority of the beſt authors I could collect, who had written upon them.

The long-accuſtomed habits of conſtant employment in medical buſineſs, and a ſerious attention to every branch of medical knowledge for ſo great a length of time, ſoon induced me to enlarge my plan, and to provide myſelf with every neceſſary implement and apparatus to make a chemical analyſis of theſe ſeveral waters on the ſpot, and to eſtabliſh, if poſſible, a fixed ſtandard of their ſeveral component parts, and deduce from thence ſome certain rules for the real medicinal uſes of ſo important a part of the Materia Medica.

The conſideration, however, that ſo many men, and ſome of them of great character, had already laboured in the ſame field, without attaining to ſo deſirable a purpoſe, would have checked a leſs ardent zeal to be of uſe to my brethren in the profeſſion, as well as to mankind in general. So numerous have been the various writers upon Mineral Waters, that an author * of no little eminence on theſe ſubjects informs us, that he has been aſſured by a gentleman of great reading, that upwards of a thouſand treatiſes have been written on the ſubject of mineral waters only ; and the celebrity of the waters of Spa, in the biſhoprick of Liege,

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* Dr. Falconer, of Bath.

Liege, in Germany, has, I think I can ſafely ſay, already excited the induſtry of at leaſt an hundred of theſe writers; and to add to ſo long a liſt of hiſtories, eſſays, &c. already made, may be deemed ſuperfluous, and abſolutely unneceſſary: and the very attempt muſt demand an apology, at leaſt, to be made to the public, for obtruding upon it any additional burden on ſo trite a theme.

Great as the improvements are that have been made, by the very eminent men of theſe days, in every part of Europe, and in all branches of ſcience, eſpecially philoſophical chemiſtry (although ſtill in its infancy) a ſcience the moſt conducive of any to uſeful diſcoveries in medicine, it may be deemed extraordinary, that the knowledge of the real compoſition of mineral waters, has not acquired equal advances to the other branches of natural knowledge.

But, however, ſufficient improvements have been already made abundantly to eſtabliſh theſe two facts; 1ſt. That many of the impregnations boaſted to be found in ſome favoured mineral waters have been ideal; 2d. That the general impregnations in mineral waters are much fewer in number than moſt of the writers on theſe ſubjects have been willing to allow.

The adoption of theſe truths will tend to ſilence all thoſe cavils, againſt any attempts to analyſe by art different mineral waters, which are founded on theſe two reaſons: 1ſt. A ſuppoſed impoſſibility of ſuch an analyſis being ever carried to the wiſhed-for point of perfection; 2d. That the imperfections in the attempts will be apt to miſlead mankind, by ſubſtituting falſe and uncertain theories in the room of long-eſtabliſhed principles and facts.

The author of the following Eſſays would not wiſh to be thought deſirous of leſſening the merits of the writers upon the ſeveral mineral waters, which he has ſelected for his analyſis: as he is ready to acknowledge that ſome uſeful diſcoveries, and very pertinent remarks and obſervations may be found in many of them. But whoever will take the trouble of reading through the numerous writers on the mineral waters of Spa only, will have ſufficient reaſon to lament how very little the real knowledge of their component parts has been advanced, notwithſtanding the great improvements held forth for the true inveſtigation of them by modern chemiſtry.

All the writers upon theſe waters, who lived or wrote before theſe acquirements were obtained, are ſo far from giving any real information of their compoſition, that their deductions are derived from falſe principles, and founded in error: and many of the later authors ſeem either to be ignorant of theſe diſcoveries, or have not properly availed themſelves of the benefit and advantages of them.

If real ſcience and great knowledge are ever united with diffidence and candour, few only of the many writers upon mineral waters have any great claim to ſo bleſſed a combination: for there are hardly any other kind of writers who aſſume the ſame degree of confidence in their own abilities, or who affect a higher or a more dictatorial ſtyle, even when they are writing from mere conjecture and ſpeculation; for ſome of them never viſited the fountains which they have choſen for the ſubjects of their diſquiſitions.

However ſimple in their compoſition many of the moſt uſeful and celebrated mineral waters ſhall be found on the chemical examination of them, good and experienced phyſicians will not readily adopt an opinion, which has been advanced by ſome of the beſt chemiſts and natural philoſophers of theſe times, that artificial mineral waters may be prepared, by the bare union of theſe ſimple component parts in pure or diſtilled water, which ſhall be not only equal, but ſuperior, in their ſalutary effects in the cure of diſeaſes, to the original mineral waters as they are prepared by nature.

I would not by any means be thought to derogate from the tranſcendant merits of two of theſe great writers, and who appear to be the moſt ſtrenuous and ſanguine advocates in advancing and ſupporting the opinion of the equality and ſuperiority even of the artificial mineral waters over the original ones, when taken on the ſpot; and ſhall only beg leave to obſerve, that my own experience, during my reſidence at one of theſe celebrated mineral fountains, and a faithful attention to the effects of the artificial as well as the natural ones, compel me, though with reluctance, to expreſs my diſſent from ſuch an opinion: and ſhall wiſh to ſtrengthen my diſſatisfaction, in oppoſition to ſuch great authorities, by obſerving how deficient the means of imitating theſe waters by art will be found; that it will appear in the courſe of this analyſis, by real experiment, that ſome of the mineral ſprings at Spa do really contain a greater quantity of elaſtic permanent gas, in their water on the ſpot, than can be united with common water by any poſſible artificial means; and this abundant union of aerial acid may poſſibly be effected with the real mineral water by ſome extraordinary degrees of preſſure in its paſſage through the earth, which can never be attained to by any artificial means on its ſurface.

In order to enable the reader of the following pages, who is not converſant in enquiries of this kind, the better to underſtand the ſeveral experiments hereafter made on the different mineral waters, of which the analyſis is attempted, through the improvements in modern chemiſtry, an introductory account will be prefixed to the analyſis, of the ſeveral agents, which are of ſuch conſequence in the formation of mineral waters, and which can alone render them ſo highly ſalutary, and of ſuch infinite uſe and importance in the cure of diſeaſes, when every other means of relief from medicinal aid is and muſt neceſſarily be defective.

THE

INTRODUCTION.

THE firſt and moſt important agent in the formation of mineral waters is the aerial acid, which is combined in ſeveral of the moſt celebrated mineral fountains in very large quantities, and which acts as the ſolvent of the ſeveral ingredients that enter into the compoſition of them, without the aid of a vitriolic or any other mineral acid.

That fixed, fixible, mephitic air, or by whatever term it is denominated, contains a real acid, *ſui generis*, can be no longer doubted of, after the very ſatisfactory experiments that were made on this ſubject by the late excellent chemiſt Mr. Bewley, and by ſeveral other eminent authors ſince his time; and which is called, by Sir Torbern Bergman of Sweden, by the general term The Aerial Acid.

The moſt common method of impregnating diſtilled or pure water with the aerial acid, is performed by collecting it, by the means of a proper apparatus, from a fermenting mixture of chalk and oil of vitriol.—It may be of ſome importance, for the clearer underſtanding the ſeveral experiments hereafter made for the analyſis of the Spa waters in particular, to ſhew, that in the preparation and collecting the aerial acid in water, there will not be the ſmalleſt portion of the vitriolic acid contained in it rendered volatile, as might be ſuppoſed, by the act of efferveſcence,

veſcence, and carried up with the aerial acid into the receiving veſſel in the upper part of the apparatus.

The ingenious Mr. Hey has made a ſet of curious experiments (vide the Appendix of the firſt volume of Dr. Prieſtley's Experiments on Air) in order to diſcover, whether the acidulous taſte, diſcovered in water which is impregnated with this kind of air, was owing to the preſence of any mineral acid in it, or only to the union of the aerial acid which it had abſorbed from the vapour of the effervefcing ſubſtances.

From theſe experiments it appears, that if a tea-ſpoonful of the ſyrup of violets ſhall be mixed with an ounce of diſtilled water, ſaturated with aerial acid, procured from chalk effervefcing with the vitriolic acid, no change whatever, either on its firſt mixture, or after it had ſtood twenty-four hours, was diſcovered in the colour of the ſyrup of violets, except what was occaſioned by its dilution in an ounce of the water thus prepared: neither could he diſcover any difference in the colour of the ſyrup, whether it was mixed with plain diſtilled water, or with an ounce of diſtilled water ſaturated with the aerial acid; but in one ounce of the acidulated water, taken from a pint of it, into which one drop only of the oil of vitriol had been put, on adding a tea-ſpoonful of the ſyrup of violets a manifeſt change of colour was ſeen in the mixture, from what had appeared before the vitriolic acid was added to it. Yet Bergman, amongſt other experiments to prove fixed air to be an acid, tells us, that it changes the blue juice of turnſole into red; and Mr. Hey confirmed it by experiment here; and moreover informs us, that when water is tinged blue with the juice of turnſole, and afterwards changed to red by the aerial acid, on expoſure again to the common atmoſpherical air, it will reſume again its blue colour.—This celebrated Swediſh chemiſt, upon this ſubject, relates, that ſyrup of violets, and many other blue vegetable juices, will not be changed to a red colour by the aerial acid; yet the tincture of turnſole, of all known tinctures the moſt obſequious to acids, inſomuch that the ſlighteſt veſtiges of acidity, which are not to be diſcovered by any other methods of trial, are by this tincture readily detected.—It may be neceſſary, for the inſtruction of the reader who has not ſtudied much this part of philoſophical chemiſtry, to obſerve, once for all, that in reading different authors who treat on theſe ſubjects, it behoves him to diſtinguiſh particularly between what is here called fixed air, and common atmoſpherical air; for all authors who wrote before the years 1767 or 1768, deſcribe the effects of air in giving a quick, lively taſte to water, and indeed to many other natural productions: they never ſuppoſed that there was really any difference between common atmoſpherical air and this peculiar kind of air, which is the ſubject of our preſent enquiry; they obſerved only, in general, that ſome certain ſubſtances, on mixing them together, as well as ſome proceſſes in nature, generate air, and others abſorb it; on a bare ſuppoſition, that the diminution of air was only a ſeparation of it from the common maſs in the ſubſtance, without any change happening in the properties of what remained behind in the maſs.

This diſcovery is due to the philoſophical ſagacity of Dr. Prieſtley; who reſiding about that time at Leeds, in the neighbourhood of a brewery (which circumſtance led him to pay particular attention to the hiſtory of air in general, and the generation or ſeparation of it from different bodies) and happening at the ſame time to read Dr. Brownrig's paper on Spa water, availed himſelf of the happy opportunity of the adjoining brewery to collect this air, by placing ſhallow veſſels filled with water within the region of the fixed air, floating on the ſurface of the fermenting veſſels; and leaving them there all night, he generally found the next morning, that the water had acquired a very ſenſible and pleaſant impregnation; and expreſſing peculiar ſatisfaction on firſt taſting this water, breaks out in the enthuſiaſm of the true ardour of genius, "that this "water was the firſt of its kind that "had ever been taſted by man."

To eſtabliſh the fact, that fixed air is a real and true acid, it will not be neceſſary, in ſuch a treatiſe as this, to give a minute detail of the various experiments that have been made by the firſt chemiſts, by which this doctrine is confirmed, that it is really poſſeſſed of all the properties that belong to acids in general, and that it is endowed with moſt of thoſe characteriſtic marks which are peculiar to acids, and which diſtinguiſh them from all other ſubſtances in nature; and fixed air muſt therefore either be a real acid, or we are not in poſſeſſion of any certain criterions of acids.

Fixed air is alſo capable of being united with other ſubſtances, as well as water, ſolid as well as fluid bodies; and ſuch ſubſtances, when ſaturated with fixed air, will in the following eſſays be ſaid to be *aerated*, to indicate that they contain that acid which is ever preſent in common air, in the ſame manner as ſuch ſalts as are ſaturated with a vitriolic acid, are denominated by the term *vitriolated*, joined to the name of the baſe with which that acid is united.

From theſe experiments, fully aſcertained, we may learn the following facts, of the perfect agreement and ſimilitude in operation of fixed air with all other acids. It excites a diſtinct ſenſation on the organ of taſte; it changes the blue tincture of turnſole to red; it attacks the fixed alkalies, renders them mild and chryſtallizable; the volatile alkalies it renders more fixed, leſs pungent, and chryſtallizes them; pure lime, when only ſaturated with it, becomes leſs acrimonious and indiſſoluble; give a ſuperabundant quantity of fixed air to pure lime, and it becomes again ſoluble; it acts in the ſame manner on terra ponderoſa. With magneſia it forms a chryſtallizable neutral earthy ſalt; with iron, zinc, and manganeſe, it forms ſalts; diſſolve theſe ſalts in water, and it will redden the blue tincture of turnſole. It exerts elective attractions, both double and ſimple; it forms a precipitate with

all

all ſubſtances diſſolved in pure alkalies; it is volatile in a great degree, and very readily, although part of it will remain tenaciouſly united with boiling water, but that will be readily detached by congelation, in a ſimilar manner as the weaker acids are concentrated by a ſimilar degree of cold; and, finally, it eagerly attaches itſelf to all phlogiſticated bodies.

It would be a tedious and unprofitable taſk to inveſtigate the ground of the theories contained in the immenſe variety, which in the earlier days of chemiſtry appeared on the ſubject of the nature and properties of certain mineral waters; the viſions of alchemy, and the jargon of the ſchool of Paracelſus, appear in many of the earlier reſearches, which took place before chemiſtry began to deſerve the name of a ſcience; and, till very lately, error and contradiction marked the generality of hypotheſes which ſpeculative ingenuity produced on a ſubject ſo remarkably fertile.

Vitriolic acid, in its common and volatile ſtate, a peculiar and unknown acid; the ſpiritus mundi of Hoffman, an occult ſpirit; an ens primum of iron, and a great variety of agents equally unſupported by reality; have been brought forward, as the principles on which the properties of waters, that were called acidulous, depend.

Though ſomething may be due to thoſe former obſervers, who, with Dr. Springfield, threw out ſimilar opinions of forming a hiſtory of mineral waters, by an appeal to experiments which refuted the former ill-grounded theories; yet, to eſtabliſh an approximation to truth, upon ſuch a ſyſtem of experiments, ſeems to belong almoſt excluſively to Venel.

The enquiries of this chemiſt, (which, as he knew little of the real diſtinctions between common and that which is now called fixed air, were not carried to perfection) appear to have directed the attention of the philoſophers on the Continent to reſearches on that ſubſtance, which was undoubtedly aerial, and the knowledge of which could alone explain the properties of theſe acidulous waters. A ſucceſſion of well-directed experiments, from the time of Dr. Black's diſcoveries to thoſe of the preſent day, has cleared up all the difficulties in regard to the peculiar properties of gaſeous ſprings; that ſubſtance, which ſo long eluded all the keenneſs of reſearch, is now in our hands, to combine or ſeparate at pleaſure: and the diſcoveries of Bergman, Bewley, &c. which have demonſtrated the acid nature of fixed air, have at laſt produced one uniform and ſimple ſyſtem, and perhaps have left us little more to learn, with regard to its properties, as an agent in the formation of mineral waters.

Many difficulties occurred in the earlier inveſtigations of mineral waters, from the appearance of earths and metals evidently inſoluble in water, being found combined with the aqueous fluid, and in ſuch a ſtate as did not correſpond to any combinations of acids or alkalies; though both, but more eſpecially the vitriolic acid, furniſhed, as was ſuppoſed, by the decompoſition of pyrites, were called to the aſſiſtance of the framers of hypotheſes.

In proportion as the properties of fixed air became more known, the ambiguity belonging to this part of the ſubject diſappeared. The honourable Mr. Cavendiſh, Bergman, and many others, nearly at the ſame time obſerved, that although aerated lime became inſoluble in water, from its union with ſome portions of fixed air, an exceſs of acid enabled water to take it up with great facility. This effect, indeed, might have been expected from the diſcovery of the truly acid nature of fixed air: and in the ſame manner terra ponderoſa refuſes to unite with diſtilled water; yet water ſaturated with fixed air will diſſolve it, though not with the ſame facility as it does lime.

The application of theſe facts to magneſia had been already made by Bergman, and a ſimilarity of effect had ſufficiently been proved. Mr. Butini, of Geneva, who did not know what Bergman had written on the ſubject, has ſtill thrown further light upon it, by a train of curious experiments. We find theſe two chemiſts agree together in ſtating the quantity of magneſia, precipitated in the common way, from a ſolution of Epſom ſalt taken up by an ounce of water, ſaturated with fixed air, at about thirteen grains; while diſtilled water can only take up one grain and a half to an ounce.

Following the path chalked out by Mr. Cavendiſh in his experiments on Rathbone Place water, Mr. Lane made ſome reſearches into the mode of union between water and iron, and traced it to the agency of the ſame ſubſtance:

the facts which have ſince confirmed this opinion, applied to other mineral waters, are too well known to need a relation of them.

The volatile alkali, which, though not very frequently occuring in mineral waters, is ſometimes preſent in them in a very perceptible manner, and probably united when diſengaged, as alkaline gas. Some waters analyzed by Mr. Cavendiſh, as alſo ſome by Malouin, ſeemed to contain a conſiderable quantity. The putrefaction of animal or vegetable matters has been ſuppoſed the only mode by which mineral waters could be combined with the volatile alkali; but the diſcoveries of later times will enable us conſiderably to enlarge our views on the ſubject of the geneſis of this ſubſtance. The inveſtigations of Lord Dundonald, and the French, have detected it in very great quantities in the mineral kingdom, as making a part of pit-coal, &c. The ambiguity of the origin of certain ſpecies of pit-coal, may render the mode in which volatile alkali is found in ſuch ſubſtances rather ſuſpicious; but experiments of a modern date ſhew, that the general ideas of the nature of volatile alkali have been too much confined, and point out a variety of circumſtances, under which, combinations producing this alkali may be effected.

The decompoſition of volatile alkali having been accompliſhed by Monſieur Berthollet, it remained that trials ſhould be made by different combinations, to form it from its conſtituent parts.

Dr. Prieſtley had ſome time ago obſerved,

ſerved, that from the contact of iron and nitrous air, as well as from diſſolving iron in a dilute ſolution of copper in nitrous acid, the production of volatile alkali diſcovered itſelf by the ſmell. Mr. Kirwan found, that when hepatic air was mixed over mercury with nitrous gas, a ſtrong ſmell of volatile alkali took place.

Our knowledge of this ſubject has been lately enlarged by Mr. Hauſſmann; who, by treating certain phlogiſticated precipitates of iron with nitrous air, has by that method alſo procured a volatile alkali.

The facts point out ſources from whence the volatile alkali may be ſuppoſed to ariſe, different from what has been generally imagined, and ſhew that its introduction into mineral waters may be effected by other means than thoſe to which it hath hitherto been confined; that is, the decompoſition of animal or vegetable matter.

The term *Phlogiſton* was firſt introduced into chemiſtry by Becher, who was born at Spires, in Germany, in the year 1625; and, from being at firſt profeſſor of medicine, became phyſician to the Elector of Mentz, and at length firſt phyſician to the Elector of Bavaria. In this ſituation he was perſecuted by all thoſe that were envious of his ſignal abilities and great eminence; and, to avoid their fury, was compelled to leave the country, and paſſed into England, and came to London; where his fame had arrived long before he appeared in perſon, and where he died in 1685. This great chemiſt and metallurgiſt ſoon perceived, that the doctrine of inflammability was falſely confined to ſulphur, which, properly ſo called, did not exiſt in animal and vegetable ſubſtances, and which were all inflammable; and maintained, that inflammability reſided in ſomething that was common to real ſulphur, and all animals and vegetables, as well as various other kinds of bodies: this ſubſtance he ſuppoſed to be of a nature which was then called *dry*, perhaps an earth he thought, and called it *Phlogiſton.*

G. E. Stahl, who was a diſciple and admirer of Becher, has publiſhed a diſtinct treatiſe on the preſence and influence of phlogiſton in ſeveral bodies: his opinion was, that this was the principle of pure fire, or the matter of fire reſident in all combuſtible bodies, and he ſtiles it the *inflammable principle,*

ple, to diſtinguiſh it from open fire, or fire in action.

The ſimple and noble idea M. Stahl formed of phlogiſton was, that its properties were different from thoſe which real fire preſents when in open action, and preſents to us its heat and light, the clear and diſtinct marks of the preſence of actual fire and combuſtion. All inflammable bodies contain real fire combined in their formation, and which is the principle, in his idea, of their inflammability; but he regarded the phlogiſtic principle to be identically the ſame in all ſubſtances, and which contained or concealed it in them, of whatever nature the bodies were, or under whatever difference of forms they were repreſented to us by our ſenſes; it is ſufficient to render them combuſtible that they contain his phlogiſtic principle, (ſuch being the language of chemiſtry in his days) in greater abundance. Thus ſulphur, coals, metals, oils, phoſphori, &c. owe all their properties to the preſence of this principle; and that the difference of its appearance in theſe ſeveral bodies when in open action, ariſes from the different combinations with which it is united, but the phlogiſtic principle ever continues the ſame, and never ceaſes to exiſt till it quits theſe ſeveral combinations, and paſſes into the ſtate of open fire. To explain the properties of fixed fire, or of fire in its phlogiſtic ſtate, M. Stahl compares, in his own treatiſe, thoſe bodies, in which it is ſuppoſed to be contained in different degrees with reſpect to quantity, with thoſe into the compoſition of which it does not appear to enter: the firſt, he ſays, have generally ſome degree of colour, ſmell, fuſibility, volatility, and combuſtibility; while the latter bodies are in general without colour or ſmell, are more or leſs fixed, are not fuſible, and incombuſtible; and all bodies that are manifeſtly phlogiſticated, by this doctrine muſt loſe the greater part of their general properties when they are deprived of this principle, and will recover them again on reſtoring to them their phlogiſton.

Thus the general doctrine of phlogiſton, firſt introduced by Becher, became improved, and rendered much more extenſive, by the natural ſagacity and wonderful abilities of the celebrated Stahl; and he raiſed on its firſt foundations ſo beautiful a ſtructure of curious and important diſcoveries, in which all the phænomena of chemiſtry

try are placed in ſo ſtrong a point of view, that new and ſtrong lights are thrown upon the darker and more intricate parts of it, and all the branches of philoſophical as well as medical chemiſtry are ſo happily illuſtrated by it, that ſuch a regular, uniform, and well-connected plan of explaining all the proceſſes both of nature and art, has been generally adopted in moſt parts of Europe for more than fifty years paſt.

Faults, however, have been found in the elegance of this ſyſtem, and objections will ſtill continue to be made to the harmony of the compoſition; and it muſt be confeſſed, that at firſt view the doctrine, however general it ought to be, is founded on the ſuppoſition, that inflammable bodies do really contain ſome ſubſtance, that is not to be found in bodies that are really not ſo; but modern chemiſtry ſeems to be in poſſeſſion of proofs, that the ſuppoſed baſis of the ſyſtem has real foundation in nature.

The real difficulty of exhibiting the ſubſtance of phlogiſton alone, formed another objection; in order to obviate the difficulties which will be cleared up hereafter, the later chemiſts, inſtead of explaining the cauſe, ſuppoſed the difficulty aroſe from the active nature of the principle, as it was called, which, on quitting any one body, immediately united itſelf to another; and, under theſe objections, which are of no great weight in reality, theſe chemiſts acquieſced the more readily, without reſolving them, as they were totally at a loſs how to ſubſtitute another mode of explaining the natural phænomena in ſo ready a manner as under the auſpices of this accommodating theory. Another objection was drawn from finding that metallic bodies did really acquire additional weight by being deprived of their phlogiſton, which, by this ſyſtem, was ſuppoſed to be a real part of their ſubſtance; but this objection is happily and by good luck done away, without any real deſign of explaining the cauſe of it.—The increaſe of weight acquired by metals in their calciform ſtate, after the loſs of their phlogiſton, is to be aſcribed to a real abſorption of air, and not to be any additional increaſe of weight from either fire itſelf, or of ſulphur in any form. And the truth of this fact is fully eſtabliſhed by a celebrated French chemiſt, who is nevertheleſs a ſtrong opponent of the phlogiſtic theory; for

Mr. Lavoiſier has proved by real experiment, that the additional weight which metals acquire by calcination is perfectly correſpondent to the quantity of air which they abſorb.

The difference in opinion which at preſent ſubſiſts between the Engliſh and ſome of the firſt French chemiſts, on the ſubject of our preſent enquiry, may, perhaps, give riſe to much future altercation; yet, if the diſpute is conducted with that temperance and candour which becomes men of real ſcience, it may ultimately fix the doctrine on a firmer foundation than the ſimplicity of the works of nature may render plauſible, or the conveniency of readily explaining her operations would tempt mankind to adopt.

Although the reality of ſuch a ſubſtance as phlogiſton exiſting in nature may ſeem at firſt view to have very little connection with the hiſtory of mineral waters, yet it may be found of ſuch importance hereafter, in an account of the compoſition of ſome of them, as to render a ſhort and familiar narrative of the origin of this diſſention not improper, for the information of ſuch readers of it as are but little converſant with ſubjects of ſo abſtruſe a nature.

Mr. Lavoiſier firſt publiſhed the opinion, that common atmoſpherical air really conſiſted of two diſtinct fluids; one of which was fit and neceſſary for the reſpiration of animals, and the ſupport of fire or combuſtion, and which therefore he ſtyles, in his different publications, vital or pure air; the other remaining and greater part of the circumambient fluid is unfit for either of theſe purpoſes, and which he calls foul or mephitic air: and he has aſcertained alſo, that the proportion of pure air in common air, was to the foul or mephitic air, in the ratio of one to four.—The diſcovery of pure air, as it is here called, is juſtly due to Dr. Prieſtley, and which in his works he calls dephlogiſticated air; which, in the proper ſenſe of the term, will ſignify air depurated of the foul or phlogiſticated part of it; yet, in the philoſophical idea of it, it means pure air. —The next ſtep Mr. Lavoiſier takes, and in this alſo he was anticipated by Dr. Crawford, is to prove, that pure air contains more fire than any other kind of air, and that, during combuſtion, it gives out this fire in the form of light and heat.

Having thus eſtabliſhed his firſt principle, he proceeds to form a new ſyſtem; and for this purpoſe advances an hypotheſis which is entirely the reverſe of the old doctrine. The ancient opinion was, that all inflammable bodies contained a peculiar ſubſtance which does not exiſt in bodies that are not inflammable: on rejecting this opinion, he defines inflammable bodies to be ſuch bodies as have a ſtrong affinity with pure air; and, in order to fix this firſt ſtone of his edifice, he proceeds to prove by real experiment, that the remains of all bodies after combuſtion, and of metallic bodies after calcination, do really contain a certain ſubſtance which they did not poſſeſs before theſe proceſſes. Now, this being an effect, may poſſibly be deemed foreign from the cauſes of combuſtion or calcination.

calcination of metals; but from theſe appearances after combuſtion and calcination, he firſt propoſes his doubts, whether, in the ſimplicity of the operations of nature, the ſuppoſition of ſuch ſubſtance as the chemiſts call phlogiſton was not entirely unneceſſary.— It may be aſked, whether, in the combuſtion of inflammable bodies, and in calcination of metals, the effects of both are not to be eſtimated by what they part with, and not from what they acquire, either after or during the operation? If ſome of the metals are calcined in vacuo, the particular ſubſtance they part with will be found to be inflammable air; ſhould any pure air remain by accident in the veſſel, water will be formed by the union of them; and, ſhould any part of the metals be in a calciform ſtate before it was ſubmitted to the operation, (which may be the caſe ſhould the metal be iron, but which cannot be ſuppoſed frequently to happen) water alſo, or fixed air, will be formed, which did not originally exiſt in the body, and which will be abſorbed by the calces in exact proportion to the increaſe of their weights.

The objection before ſtated, of the defect of exhibiting the ſubſtance of phlogiſton ſingly, began annually to receive further illuſtrations from the publications of Dr. Prieſtley, till, from theſe experiments, and many other ſuggeſtions by ingenious men, it was inferred, that inflammable air really exiſted in bodies, before its extrication from them in a concrete form, till it manifeſtly appeared, that inflammable air in its fixed ſtate was the very ſubſtance which the ancient chemiſts called phlogiſton, and that it was really poſſeſſed of every character and property which they attributed to this occult quality, as its opponents then and ſince their times have called it: and it ought no longer to be conſidered as a mere hypotheſis; but it may be clearly demonſtrated to exiſt in its aerial form, with as many diſtinct properties, and to be as true and abſolute in the mode and form of its exiſtence, as any other ſpecies of air whatever.

The theory of chemiſtry, which may be called philoſophical chemiſtry, is much indebted to the induſtry and abilities of ſome of the moſt celebrated French chemiſts, as well as to the labours and ſagacity of Dr. Prieſtley in this country; and great obligations are due to both, and particularly to Mr. Lavoiſier, for our advances in the knowledge of the nature and compoſition of acids.

That pure as well as common air ſuffers great diminution in their quantity, on uniting either of them with nitrous air, and alſo during the combuſtion of ſome particular bodies, we owe to Dr. Prieſtley; but the ſingular connections and relations of pure air with the different acids reſulting from the union of them, and many other improvements in this part of chemiſtry, were firſt obtained by Mr. Lavoiſier; Mr. Kirwan had indeed, in different papers in the Philoſophical Tranſactions, taught the union of pure air with the phlogiſtic principle, in the formation of fixed air, and a variety of reſults from thence in different modifications of it; but it is from the French chemiſts that we learn, that all the acids conſiſt of two principles, one of which is peculiar to each particular acid, and this they eſteem to be a ſimple undecompoſible ſubſtance; and the other, pure air, reduced into its ſmalleſt volume, which ſignifies it to be deprived of moſt part of its ſpecific heat, and this ſtate of it is called its concrete ſtate.

The firſt of theſe principles they ſtyle, the baſis of the acid, and the latter to be pure air, and which, in their modern nomenclature, is called the oxygenous principle. Thus the vitriolic acid conſiſts, in their opinion, of ſulphur as its baſe, and pure air in a concrete ſtate.

This doctrine of the compoſition of acids is admitted by the defenders of phlogiſton, except that ſome of the French chemiſts, who are alſo phlogiſtonians, unite phlogiſton with the different baſes of the acids, and which they ſay they will loſe on uniting with the pure air; and it muſt be left to them to prove how this union can take place without forming a new compound, in oppoſition to Mr. Lavoiſier's elementary nature of theſe baſes.

In the opinion of ſome writers, ſuch a union of pure air with phlogiſton, muſt either form the compound of water, as the experiments of Mr. Cavendiſh are intended to ſhew, or fixed air, according to the ſentiments of other authors. Mr. Kirwan is of opinion, that the only circumſtance by which water has been clearly proved to be the reſult of the union of inflammable air and pure or dephlogiſticated air, in that in which one or both of theſe airs were expoſed to a red heat; and moreover it is apparent, that in lower degrees of heat fixed air will be the product of the union of the two airs.—The idea of the vitriolic acid, whoſe baſis is ſulphur, of Mr. Lavoiſier, is oppoſed by one of the moſt intelligent of the Engliſh chemiſts, on theſe grounds—that the radical principle of this ſalt, abſtracted from water, which it always contains, by uniting with phlogiſton, forms ſulphur as a compound; and that with fixed air it becomes common fixed vitriolic acid; but with both pure air and fixed air, in different proportions, it forms volatile vitriolic acid, of different degrees of volatility.

The nitrous acid is involved in much greater obſcurity, in relation to its component parts, as well as in the variety of its effects; but in ſuch an introduction, that is prefixed to an analyſis of ſome mineral waters, it will be ſufficient to ſay, that the conſtituent principles of nitrous acid are fixed and inflammable airs, with both phlogiſticated and dephlogiſticated airs, with different proportions of theſe principles, as the acid proves red, yellow, green, or blue, with different degrees in the intenſities of the colours, or pale and colourleſs, united with the peculiar acid as its baſis.

Common *marine acid* is ſaid to conſiſt of a peculiar baſe united to phlogiſton, with a certain proportion of fixed air, to both of which the baſis ſeems to have a ſtrong affinity; for, in proportion as it is deprived of its phlogiſton, it acquires a ſtronger affinity to fixed air; and the acid reſulting from the union of the dephlogiſticated baſis with an exceſs of fixed air, is called the dephlogiſticated marine acid.

The properties of this acid, ſince the diſcoveries of Monſieur Berthollet, ſeem alone, in Mr. Kirwan's opinion, to afford any plauſible ground for the antiphlogiſticated theory. According to this theory, the common marine acid conſiſts of a peculiar baſe, united to a ſmall proportion of pure air, or the oxygenous principle; and the dephlogiſticated marine acid differs from the common one only in containing an exceſs of this principle.

The common marine acid deſtroys vegetable colours, by depriving the colouring matter of its phlogiſton, and ſaturating it with fixed air; and the addition of an alkali will not reſtore the colour, as alkalies cannot reſtore the phlogiſton.

Aqua regia is formed by mixing equal quantities in bulk of common marine acid, with ſtrong colourleſs nitrous acid; and in this compoſition, the marine acid will deacidify in great meaſure the nitrous one, while the nitrous acid dephlogiſticates the marine; or, which is the ſame thing, the marine acid will take up great part of the fixed air of the nitrous, while the nitrous acid will take up the phlogiſton of the marine; and hence part of the nitrous acid is converted into nitrous air, which unites to the undecompoſed part of the nitrous acid, and forms a phlogiſticated nitrous acid; and hence aqua regia becomes of a red colour.

The three principal mineral acids can alone demand any particular attention on this occaſion; hardly any other acid, except the aerial acid, already explained, can be of ſufficient importance to require a particular conſideration.

There is no queſtion that has engaged the attention of philoſophers and naturaliſts more earneſtly, than by what means the different ſimple Thirmal's baths and ſprings, which are found in many parts of the world, of ſuch different latitudes and temperatures, and the different impregnations that are found in ſome of them, together with the ſeveral cauſes of the different degrees of heat which conſtitutes them either ſimple, tepid, or hot baths, or warm medicated waters; and there is no queſtion on which the beſt of theſe writers, and the beſt informed chemiſts, have given leſs ſatisfaction.

It unfortunately has happened, that thoſe arguments which have been brought forward to explain by what means warm medicinal ſprings have acquired their ſeveral degrees of heat, will not apply with equal force when they are directed to ſolve the difficulty, how ſimple unimpregnated warm baths have acquired their ſeveral degrees of warmth.

That *dernier reſſort*, to conceal our ignorance upon every queſtion that ariſes of difficulty, in the explanation of the phænomena within the upper part of the earth's ſurface — the central emanation from a vaſt maſs of fire or heat placed in the center of the earth—although received in a favourable light by many great philoſophers of theſe times, cannot poſſibly be admitted in our preſent caſe; as it muſt equally affect all adjoining ſprings of common water in the ſame parts, which we find to be by no means the fact; and perhaps the ſuppoſition itſelf may prove groundleſs, and unneceſſary to explain other natural appearances.

Some further weight may, perhaps, be allowed to ſubterranean local heat, occaſioned by effervеſcent ſubſtances, in producing a degree of heat, that may lie extrinſic in the bowels of the earth, from the paſſage of the water percolated through different ſtrata at ſome remote diſtances, yet within the ſphere of the activity of theſe heating ſubſtances.

In volcanic countries, the different ſprings, both ſimple and mineral, may be ſuppoſed to receive very uncertain degrees of heat from the different ſtates of the neighbouring volcanos: but the volcano itſelf may be produced from ſimilar ſubſtances acting on each other, in the converſion of abſolute into ſenſible heat, till they break out into actual fire, and form eruptions from the mountains. The ſuppoſition of partial ſubterraneous fires, adjoining to the currents of the fountains within the earth, appears without the leaſt real grounds of ſupport. If the term, *ſubterraneous fire*, has any ſpecific meaning, it muſt denote the combuſtion of accumulated bodies of inflammable ſubſtances: another difficulty will ariſe from the infinite conſumption of the combuſtibles, and a ceſſation by degrees of all poſſible warmth being obtained from thence; whereas the fountains have preſerved the ſame degree of heat, and poſſibly without the leaſt diminution of it, through unnumbered centuries.

I ſhall leave the reader to embrace whichever of theſe reaſons ſhall appear moſt plauſible to him; perhaps he may find it moſt reconcilable to common-ſenſe to ſuppoſe, that theſe different degrees of partial heat in diſtinct and ſeparate fountains, that are found in ſeveral parts of the world, may ariſe from large bodies of pyrites, or other mixed ſubſtances capable of exciting great degrees of heat when moiſtened with water; and if they are in immenſe bodies, they may lie remote from the courſe of the fountain, and beneath the detection of human inquiries, and do not communicate any impregnations of themſelves to the waters through their great diſtance from them.

Notwithſtanding the attention of philoſophers has been for a long time turned to the inveſtigation of the nature and origin of the aerial acid, as well as the reality and properties of phlogiſton; and experiments have been multiplied throughout all Europe, directed to both theſe points; the opinions of the chemical world are ſtill unſettled on theſe ſubjects; and in this reſpect chemiſtry is, as it was before ſaid to be, in its infancy. Paſſing over the ſpeculations, which the ſtill earlier days of chemical knowledge produced in regard to aerial fluids, the two theories which, at this period, divide the general body of chemiſts, deſerve ſome notice on a ſubject like the preſent.

The ſuperior ſeducing ſimplicity of the antiphlogiſtic doctrine appears, on examination, when applied to the matters before us, as well as in general, deluſive and unſatisfactory, ſince, by the introduction of an elementary ſubſtance, under the title of *Matiere Charbonneuſe*, to ſerve as the baſis of fixed air, the liſt of chemical elements is unneceſſarily increaſed, and, in fact, two inflammable principles, inſtead of one, are acknowledged in certain bodies.

It is ſaid, that in the operations with charcoal, plumbago, and the various ſubſtances to which *Matiere Charbonneuſe* is attributed, that the fixed air, which reſults, has no connection with the inflammable air or phlogiſton, but that it is a combination of the pure air with the proper baſe of mephitic acid: but it has reſted on the adherents to the French hypotheſis to demonſtrate, why *Matiere Charbonneuſe* is not to be conſidered as a mere verbal diſtinction, ſince from the evidence of facts it differs not from what thoſe of the other opinion call phlogiſton. How is it proved, that charcoal is the only proper baſis of fixed air, and a peculiar matter, when it has been already proved, that the effects reſulting from the union of pure air and charcoal are produced equally from that fluid and metals? Although it has been ſaid, that *charbon* exiſts in metals, the idea has been always hypothetical: if the preſence of plumbago in iron may prove a valid objection, the production of the ſame effect with zinc, braſs, lead, and other metals, is ſtill ſufficient to demonſtrate the fact. If *charbon* does exiſt in metals, as we know what alone can be procured from them in vacuo, inflammable gas, then that air, and coaly matter, come at laſt to the ſame thing.

The identity of *charbon*, and the inflammable air, is further evinced by the experiments of Monſieur de Laſſene and Pelletier, who found that zinc, heated with cauſtic alkali, after diſengaging a little inflammable air, leaves the alkali combined with aerial acid. And Monſieur Metherie has made a beautiful ſet of experiments, by which it appears, that all thoſe metals which will detonate with nitre, leave after deflagration the alkali effervefcent.

If then, as it appears from the argument of fact, that *Matiere Charbonneuſe* ſimply anſwers to the idea of phlogiſton, the ſubſtitution of which has preciſely the ſame effects ; it can ſcarcely be deemed accurate or philoſophical, to make a diſtinction between them, which uſeleſsly enlarges the number of ſimple ſubſtances ; and the experiments which have been made on combinations producing aerial acid, ſtill further evince the inutility of the ſubſtitution of *Matiere Charbonneuſe* in the chemical nomenclature.

Although, from the intricacy and ſubtlety of the ſubject, and the imperfection ſtill remaining in our knowledge of chemical agents, hypotheſis is ſo often inapplicable, and even experiment ſo indeciſive ; the weight of poſitive fact would ſeem to be in favour of the opinion ſo ably defended by Mr. Kirwan, although adopted by few at preſent on the continent, Mr.

Sennebier, and ſome others, excepted.

Analyſis and ſyntheſis ſeem to have approximated, as near as the matter would allow, to a proof of the compoſition of fixed air from the inflammable and pure gaſes. Experiments collected from the great number of them, which the induſtry of chemiſts has lately multiplied to an enormous bulk, are ſingularly repugnant to Mr. Lavoiſier's theory, and throw real light on the nature of fixed air.

If braſs, zinc, &c. as metals, are ſimple ſubſtances, and treated with pure air, or ſubſtances containing pure air, only receive the oxygenous principle, it is inexplicable how, under ſuch circumſtances, they again do not yield the elementary ſubſtance; they could only on that ſuppoſition receive, but give out very large quantities of aerial acid; a fact more remarkably exemplified in the amalgamation of mercury and lead in pure air.

Metals and charcoal treated together by heat as elementary bodies, ſhould furniſh nothing; but it is well known, that large quantities of inflammable air are produced; and when pure air is preſent, the aerial acid is always the reſult.

In the experiments made on braſs, zinc, &c. with pure air, our preſent knowledge is ſufficient to give us poſitive information, that they furniſh nothing but inflammable air: and the ſame has been ſhewn by Mr. Kirwan, with amalgamas treated by a diſtilling heat.

The ſyntheſis of the fixed air, in theſe and ſimilar forms of exhibiting it, ſeems to be obvious, and not to be explained away by the antiphlogiſtic doctrine; if the experiments with charcoal ſhould wear any ambiguity, from the French hypotheſis relative to that ſubſtance, an appeal to fact is to be made, as experiments are recorded in which charcoal, expoſed in vacuo to violent heat, was found to diſappear altogether, and, at the ſame time, nothing was produced but inflammable air.

Many of the facts related by Hermſtadt, de Laſſone, Pelletier, &c. afford the ſtrongeſt evidence in favour of this idea of the nature of fixed air, and are inexplicable on Mr. Lavoiſier's principles.

A variety of experiments, exhibiting decompoſitions of fixed air, ſeem to ſhew that the analyſis anſwers to the ideas of the ſyntheſis: as thoſe of Mr.

Monge

Monge with the electrical ſpark; thoſe in which the calces of metals, after having abſorbed fixed air, give out pure air, and the metals are revived; the phænomena of certain calces, which, according to the degree of heat, give out fixed or pure air; the general nature, and the appearances of the metals occurring in the earth in a calceform ſtate, without ſuffering any change by art; and laſtly, Mr. Hermſtadt's experiments with mangeneſe, which ſeem to make directly in favour of ſuch a combination.

It is ſufficiently obvious why the immediate application of pure to inflammable air, does not in all caſes generate mephitic acid; for when the two airs contain their full proportion of heat, the union cannot take place till the abſolute heat is converted into ſenſible,

ble, or ſet at liberty :—for it would appear by ſome experiments lately made, that even in this ſtate a reciprocal action may take place in peculiar circumſtances, although the experiment of Dr. Prieſtley, with pure and inflammable air acting on each other through a bladder, is too inaccurate to furniſh a deciſive inference, as the putrefaction of the bladder might ſupply ſome fixed air.

In this introductory part, it will be proper to collect together all the general obſervations that are to be made on that claſs of mineral waters, which are commonly eſteemed and called ſulphureous, before we proceed to the hiſtory and analyſis of the mineral waters of Aix-la-Chapelle and St. Amand.

The unphiloſophical and ſelf-intereſted conteſt that was kept up at Bath for ſo many years, and maintained with more warmth than good manners or ſcience—whether ſulphur, properly ſo called, was ſoluble in water, without the aid of an intermediate ſubſtance, or an alkaline ſalt being united with it—gave ſuch a general diſguſt to the ſubject, that it will be with great caution I ſhall venture on the diſcuſſion of ſo intricate a problem; which the ingenuity of all the former chemical inquirers were unable to ſolve, and the penetration of the philoſophers of this age can be barely ſaid to have elucidated.

It can hardly be worth while to examine, with any degree of attention, the various and diſcordant opinions, which the numerous early writers on this ſubject, have given to the world, as a more improved chemiſtry has ſhewn the greater part of them to be altogether inadmiſſible.

Before the modern diſcoveries were known, Dr. Lucas had propoſed a theory, which he thought adequate to the ſolution of the difficulties attending a real ſulphureous impregnation of mineral waters. He being fully ſatiſfied that no *hepar ſulphuris* was preſent in them, and finding other modes of union between ſulphur and water little agreeable to the facts then generally known, concluded that its exiſtence, in a perfect ſtate, was to be rejected from every ſpecies of mineral water.—This Hoffman and Liſter had fixed before him; but Lucas advanced ſtill further, and endeavoured by plauſible arguments to ſupport an hypotheſis, that ſhould account for the appearance of actual ſulphur attending certain mineral waters, and from hence called ſulphureous. Taking the received ideas of the component parts of ſulphur for granted, he conceived that when accompanying mineral waters, it was formed extraneouſly: the acid contained in the water meeting with phlogiſtic matters in the earth, which ſublime and meet on the ſurface of the water, and that the ſulphur of them was only to be referred to that combination.

A contraverſion of this hypotheſis appeared from Dr. Rutty, who ſupported the oppoſite opinion with ingenuity, and publiſhed in the Philoſophical Tranſactions a general review of the facts and evidences which he imagined tended to prove the preſence of ſulphur, perfectly formed, in the hepatic waters; and was indeed able to ſhew, that its appearance in them was not always owing to external combinations, though he was little able to tell in what manner the water was diſpoſed to a union with ſulphur. He obſerved, indeed, the alkaline ſalts belonging to certain hot mineral ſprings, and ſeems inclined to ſuppoſe that the menſtruum proper for the ſolution, was to be looked for in them. The immediate oppoſition of facts, to the exiſtence of any thing like hepars in the ſulphureous waters, obliged many inquirers, who were favourable to the ſuppoſition of formed ſulphur making a component part of theſe waters, to adopt an idea that ſulphur might be ſuſpended, though not diſſolved, by means of a ſubtle diffuſion of it.

Of this claſs is an author, who publiſhed his arguments not long before the problem in queſtion received further illuſtration. In theſe he attempts to account for peculiarities, in the ſulphurated waters, inexplicable on the common principles; and obſerves, that by ſublimation from ſubterraneous fires, ſulphur might acquire a ſufficient degree of diviſion to be ſuſpended in water. This, like the preceding opinions, it is hardly neceſſary to controvert, or obſerve that it is entirely unſupported by fact, and militates againſt the general principles of chemiſtry; as the ſulphur, if preſent, is evidently in a ſtate of union.

At a late period, reſearches in the pneumatic chemiſtry detected a permanently elaſtic fluid, which had been paſſed over by Dr. Prieſtley: the more obvious properties of which were, a peculiar fetor, inflammability when mixed with certain other airs, and a power of diſcolouring ſilver and other white metals.

It was found that this gas, when united in a certain proportion to pure water, communicated to it the ſmell, taſte, and many other characteriſtics of the ſulphureous waters.

Bergman, who firſt began to make regular and connected obſervations on this ſubject, found that water artificially impregnated with the air diſengaged by acid from hepata, &c. though yielding no precipitate to acids in general, threw down, on the addition of dephlogiſticated and highly-concentrated nitrous acid, a powder, which, being collected and dried, was actual ſulphur. He obſerved, that from ſuch waters, ſilver, diſſolved in nitrous acid, was precipitated black or dark brown, and the precipitate was ſulphurated: and that arſenic, in its pure ſtate, was gradually converted into orpiment. He formed a theory of the compoſition of hepatic air, on the principles of which he accounted for theſe appearances, as well as for thoſe of actual ſulphur in its concrete form attending the ſulphureous waters; ſuppoſing, in the latter caſe, a power in the pure air of the atmoſphere to decompoſe hepatic gas, by ſeizing on its phlogiſton.

Subſequent reſearches have been made by Sennebier, Kirwan, &c. by which the properties and chemical habits of this air have been much elucidated.—The effects of certain combinations have appeared rather to militate againſt ſome of Bergman's opinions. It is found, that with pure and nitrous gas the hepatic air deflagrates, and that ſulphur is depoſited ; that when nitrous or vitriolic airs are added to the hepatic, a diminution and reciprocal action takes place, and ſulphur is found incruſting the veſſels ; that the alkaline and hepatic airs act on each other ; but that with common or pure air no decompoſition took place, though they remained together eight days. The action of fixed, inflammable, and other elaſtic fluids ſeemed to be little or none.

Dr. Watſon, biſhop of Llandaff, was led, from the conſideration of certain hepatic waters, Harrowgate in particular, to propoſe a queſtion, Whether they were not impregnated with a peculiar air, which he ſtyled Hepatic, and from which they received their characteriſtic qualities? before he was acquainted with what Bergman had done on the ſubject of the hepatic gas. He aſks, whether this air, and the inflammable air ſeparable from ſome metallic ſubſtances, conſiſts of oleaginous particles in an elaſtic ſtate? This part of the conjecture may, perhaps, not be admiſſible; but the learned biſhop's claims to the diſcovery of this aerial impregnation ought not to be overlooked, though he modeſtly gives it up, as well as any future merit in its proſecution, to Mr. Bergman; who, ſince this time, has, to the great loſs of all true philoſophical knowledge, at a time when the higheſt expectations were entertained of his further illuminations of every part of chemiſtry, ſunk under infirmities and diſeaſe, in conſequence of his unwearied application to the improvement of his favourite ſcience.

The application of the facts beforementioned, to the compoſition of hepatic waters is obvious. The manner in which the hepatic gas is extricated in the bowels of the earth, is explained by Bergman, by ſuppoſing the decompoſition of hepatic matters, which is formed there from the union of ſulphur with lime, magneſia, or alkali, to take place by various means. This explanation, however, from the rare occurrence of real hepata being found in theſe waters, and other incidental occurrences, ſeems to be ſtill involved in ſome difficulties. Perhaps Mr. Gengembre's experiments, and ſome more modern obſervations on the variety of bodies that ſeem to be concerned in the production of this air, may throw conſiderable light on other and more probable modes, by which ſo important an agent is preſented to be combined with different waters in the deep receſſes of the earth.

For ſome time very few ſubſtances only were known to yield hepatic air, as the hepata, ſulphureous ores of lead, zinc, &c.—We now know, that it is commonly found in coal-pits, and Bergman diſcovered it in native Siberian iron; many inſtances are given, in which wood remaining for a long time in common water has been obſerved to communicate to it ſome of the properties of hepatic waters; and ſea-wrack, calcined to a certain point, impregnates water with the ſmell and taſte of hepatic air. Some of the effects of hepatic air are manifeſted in the putrefaction of certain animal ſubſtances; from the diſcoloration of ſilver, as well as by the ſmell and taſte, this fact has particularly appeared in blood. It has been ſuppoſed by ſome writers, that common ſalt, by calcination, or by putrefaction, will impart to water a ſulphureous ſmell and taſte. Sulphur, with oils, charcoal, ſugar, and plumbago, will yield hepatic air, when properly treated, according to Mr. Kirwan; who did not ſucceed in repeating ſome of Mr. Gengembre's experiments, moſt probably from the want of a due degree of heat being employed.

In general, the livers of ſulphur will not yield hepatic air without the addition of an acid, and the marine acid is beſt adapted for this purpoſe.—Every ſpecies of hepatic air turns the tincture of lacmoſs red. Hepatic airs, extracted from different materials, differ very much in their ſolubility in water; but the moſt remarkable appearance in the union of hepatic air with water is, that it is not permanent; yet the water in no degree decompoſes the hepatic air. The moſt ſenſible teſt of hepatic air is the ſolution of ſilver in nitrous acid; inſomuch that, in proportion to the degree with which the nitrous acid is ſaturated with ſilver, this, even by contact with hepatic air, however mixed with other airs or ſubſtances, becomes red, brown, and black; and theſe precipitates are only ſulphurated ſilver, and when the acid is not largely ſaturated with the ſilver, the precipitate will be re-diſſolved. As to the properties of water ſaturated with hepatic air, it turns the tincture of lacmoſs red; it does not affect lime-water; the ſolution of earths in the mineral acids are not altered

tered by it; with the marine ſalt of iron it forms a white precipitate, with the nitrous ſalt of copper a brown precipitate, and the liquid is changed from blue to green; with copper vitriolated a black precipitate; with a variety of other habitudes, with different metallic ſolutions, not neceſſary to be repeated here: and for an accurate account of hepatic air, the reader is referred to Mr. Kirwan's experiments in the firſt part of the Philoſophical Tranſactions for the year 1786.

The difficulty of uniting the ſulphur, if there is any, in theſe waters, with them, (although true hepata, or livers of ſulphur, are rarely to be found in them) does not ariſe from any want of proper ſubſtances to form ſuch a union, for many of them contain both mineral alkali and different abſorbent earths: whether the diffuſion of theſe ſubſtances in ſo great a body of water renders them incapable of acting with a ſufficient force to diſſolve the ſulphur, or that the degree of heat in the water is not ſufficient to form the union, I do not pretend to determine; but I know that the hotteſt water in the neighbourhood of Aix-la-Chapelle, and the heat of which far exceeds the heat of any of the ſprings in the city of Aix, diſcovers no ſigns of any hepatic air, though the other contents of this water are entirely ſimilar to what is found in moſt of the waters in that place. Yet nothing is more difficult and rare, than, in treating the generality of what are called ſulphureous waters, to be able to detect, by any teſt whatever, any real ſulphur contained in them. There are ſome ſulphureous

ous waters that, with the addition of a very ſmall quantity of liver of ſulphur, will form precipitates with metallic ſolutions; yet, if you add to them only the pure acid, even the dephlogiſticated and highly-concentrated nitrous acid, no precipitate of ſulphur whatever will appear.

M. Macquer has remarked, that if you put a few drops of a ſtrong metallic ſolution into theſe waters, the hepatic air will diſappear, becauſe, he ſays, this vapour will attach itſelf to the metallic ſubſtance, and thereby loſe its volatility.

If ſuch conjectures are admiſſible in chemiſtry, it has been advanced by ſome writers of eminence, that hepars have formerly exiſted in theſe waters; but they, through the long lapſe of time, have been decompoſed, and nothing remains at this time, but the mere ſmell and other faint veſtiges of them.

And ſome authors have explained themſelves in this manner concerning their opinion of ſulphureous waters:—Hepars, they ſay, naturally tend to decompoſition; the ſulphureous part of them diſſolves through the diſſipation of the phlogiſton, which, quitting the acid, this combines with the alkaline ſubſtances that had held the ſulphur in a ſtate of ſolution: and this decompoſition ſhall take place ſooner or later, according to the nature of the hepar; if compoſed of calcarious earths, the ſooneſt: the greater the quantity is, and the greater the expoſure on large ſurfaces, aſſiſted by greater degrees of heat, the ſooner it will be accompliſhed.

They ſay alſo, that the property of diſcolouring ſilver, mercury, and other white metallic ſubſtances, is a moſt fallacious teſtimony of the preſence of real ſulphur; for many ſubſtances, very foreign from the principles of ſulphur, will have the ſame effect. And in the formation of ſulphur itſelf, in proportion as it combines with the intermediate ſubſtance it never remains pure, but ever retains ſome portion of a fuliginous or coaly matter, and which adheres cloſely combined with it; and that it is this ſubſtance which produces the effects of the hepars, in precipitating with metallic ſolutions; and on this account the precipitate will appear black, very different from the appearance of the precipitate formed with the ſame metallic ſolutions in the waters of Aix-la-

Chapelle,

Chapelle, and other noted ſulphureous waters, as will manifeſtly appear hereafter; and, moreover, that theſe waters do not really contain any ſubſtance that is combined with the vitriolic acid.

But in order to cloſe what I have further to ſay on the ſubject of hepatic air, ſo frequently deemed the criterion of real ſulphureous waters, Mr. Monnet is of opinion, that this vapour is ſo far from being always the reſult of the decompoſition of ſulphur detached from vitriolic acid, that he thinks it to be purely phlogiſtic, or nearly ſo; and that whenever a pure phlogiſton is exhaled, it will ever have the ſame ſmell: and a vapour, ſimilar in ſmell, will exhale from putrifying vegetables, and which will alſo diſcolour white metallic bodies. The vapour detached from ſulphur and iron filings, moiſtened with water, was never deemed to be actual ſulphur, however ſimilar it may appear to hepatic air. If you put a piece of heated pyrites into cold pure water, in a veſſel that may afterwards be cloſed up, it will give the water the taſte and ſmell of a ſulphureous one, and it blackens ſilver; and it is the opinion of Mr. Monnet, that the volatile ſpirit, which is detached from the pyrite, is confined and diſperſed in the water by the decompoſition of it. This phlogiſtic vapour, ſeparated from the acid, remains poſſeſſed of all the properties of the maſs. A ſimilar effect is produced in forming a ſulphureous mineral water in the water of a blackſmith's ſhop, in which he occaſionally quenches his heated iron; and this vapour is ſo extremely volatile, that it very ſoon eſcapes from the water, and is diſperſed in the open air; and the water then will in no reſpect differ from common water, if no other ſubſtances ſhall remain diſſolved in it.

Thus it appears then, that the chemiſts are not at preſent on any ſettled plan of the nature and compoſition of hepatic gas, though moſt ſeem to agree, that ſulphur enters into it as a component part. The manner in which that ſubſtance is dilated into a fluid permanently elaſtic, is explained with ſome diverſity; Bergman, who has made the greateſt advances towards the elucidation of it, has ſuppoſed that the preſence of phlogiſton is neceſſary to form the bond of union between ſulphur and the matter of heat; and ſupports his opinion on the eaſy decompoſition of this air by nitrous acid, which he attributes to the avidity with which that acid attracts the phlogiſton of the compound, and ſets the diſunited parts at liberty; to the ſame purpoſe he produces the decompoſition by vital air. Mr. Gengembrè, from experiments, in which he obſerved, that the hepars did not yield hepatic gas, except when formed by the humid way, or diſſolved in water, conceives the decompoſition of water neceſſary to the formation of this air, the component parts of which he conceives to be aqueous inflammable air and ſulphur, of which the ſulphur does not all burn, but is in part depoſited during the inflammation of the other part. An experiment made by Mr. Gengembrè, on this ſubject, is worthy of attention: he expoſed ſulphur to the focus of a burning-glaſs, over mercury, in inflammable air, and relates, that a part of the ſulphur was diſſolved, while the inflammable aſſumed the nature of hepatic air: he produces many more facts, to which applying Mr. Lavoiſier's principles, he endeavours to ſupport his opinion. The decompoſition of hepatic by pure air is readily explained on this theory, as water is formed on the addition of the latter, and the ſulphur, deprived of its ſolvent, is precipitated. One of the laſt authors, an Engliſh one, on this ſubject, who has treated it with the greateſt intelligence and accuracy, and on this account it is not neceſſary to mention his name, conſiders this gas as ſimply ſulphur, enabled by the matter of heat to aſſume an aerial or permanently elaſtic form.

ALKALINE AIR AND WATER.

As the common marine acid air may be deemed to be the vapour of the ſpirit of ſea ſalt; under the ſame method of treatment, by receiving it into a veſſel filled with quickſilver, inverted into a baſon with quickſilver in it, an alkaline, though not a pure one, may be procured from the volatile ſpirit of ſal ammoniac put into a thin phial, and heated with the flame of a candle, by which means a great quantity of vapour may be collected, paſſed through the quickſilver, where it will remain in the form of a tranſparent permanent air, not condenſed by cold. By the ſame means it may be procured from ſpirit of hartſhorn, or ſal volatile, either in a fluid or fixed form, and from any of theſe volatile alkaline ſalts, produced by the diſtillation of ſal ammoniac with fixed alkalies. But from this method of preparing theſe volatile alkalies, it will be found that this air will contain a greater quantity of fixed air, mixed with ſome alkaline air in the compound. The beſt method of procuring a pure alkaline air, will be to make uſe of a volatile ſpirit of ſal ammoniac, prepared by diſtillation with ſlaked lime, which contains no fixed air; and the quantity of pure alkaline air, that by theſe means may be procured, will be nearly equal to the quantity of acid air detached from an equal quantity of the ſpirit of ſea ſalt. This alkaline air will be readily imbibed by water, and by its union with it will form a very ſtrong ſpirit of ſal ammoniac, perhaps a ſtronger one than can be made by any other means. And by uniting this alkaline air with acid air prepared from ſea ſalt, a white ſalt may be procured in a ſolid form, which will prove to be common ſal ammoniac, or the marine acid united to the volatile alkali.— Fixed air, admitted to this alkaline air, formed oblong ſlender chryſtals, that covered the ſides of the veſſel with net-work, and which were the volatile alkaline ſalts which the chemiſts get in a ſolid form by the diſtillation of ſal ammoniac with fixed alkaline ſalts. The property of alkaline as well as acid airs haſtily to diſſolve ice, when that ſubſtance is expoſed to the action of them, has been often obſerved; the heat, which neceſſarily paſſes in ſuch caſes from an abſolute to a ſenſible ſtate, during the time that the elaſtic fluids are attracted and abſorbed by the ice, will ſufficiently account for the ſpeedy effects of this operation.—The further proſecution of experiments with alkaline air has been anticipated by a previous account, to ſhew that volatile alkalies may be introduced into mineral waters by other means than what they have been confined to by the generality of writers upon them; namely, the decompoſition of animal or vegetable matters by putrefaction.

ALKALINE WATERS.

Alkaline waters are diſtinguiſhable, beſides the piquant flavour and effervefcence with acids, by a peculiar lixivious taſte, by decompoſing many earthy ſalts in ſolution, and turning green the blue vegetable juices: they are all more or leſs impregnated with fixed air, in conſequence of which they exhibit many appearances in common with gaſeous waters, though they are in fact of a contrary nature. In the waters in queſtion, the very great quantity of fixed air, which is found uncombined, muſt almoſt render it impoſſible that the alkaline part of their compoſition ſhould exiſt in a pure ſtate, or even in one approaching to it; yet the properties which a complete neutralization from ſo weak an acid would preſent, can hardly be looked for, as is evident from the effects of combination with other ſubſtances.

Several parts of Germany, and Auvergne in France, furniſh waters of this kind, taking their principal characters from a mineral alkali contained in them. Mr. Monnet has obſerved, that the mineral alkali is preſented in theſe waters in two different ſtates; one, in which it is yielded well chryſtallized, and ſuch as is procurable from the lixivia of ſoda and marine ſalt; but that it is more commonly in a lixivial ſtate, as in the waters of Mont d'Or and Bourbon; and that in ſome waters it is ſo maſked and diſguiſed, that a great number of the examiners of mineral waters have been baffled in their attempts to inveſtigate the nature of this ſalt.

The manner in which he conceives the decompoſition of the ſelenite may be avoided, he explains in the following manner: When a looſe mineral alkali is preſent, he ſuppoſes, that in the ſtate, which he calls lixivial,

vial, the alkali does not manifeſt all its ſaline properties; and relates, that he has made experiments on this alkali with a ſolution of ſelenite, which it did not alter.

Till the nature of the waters examined by Mr. Monnet are more exactly known, ſome ambiguity evidently appears in his account of the ſtate of the alkali in them, which he calls lixivial, and to which he attributes ſuch peculiar properties.

The preſence of the mineral alkali uncombined, has often been the cauſe of great difficulties in the analyſis of waters, containing with it other ſaline bodies, particularly common ſalt. A mode has been pointed out, by an ingenious phyſician of Turin, which ſucceeds very well in ſeparating and aſcertaining the quantity of the mineral alkali; to which Bergman's method was inadequate. Mr. Gioanetti diſſolves all the foſſil alkali in diſtilled vinegar, and diſſolves the terra foliata, or the natron acetatum, in alcohol, after chryſtallizing it. If ſea-ſalt is mixed with the natron acetatum, it is not taken up by the vinegar; from which the mineral alkali is eaſily recovered, and its proportion to the original maſs directly aſcertained.

Though the univerſal diſperſion of mineral alkali uncombined with the mineral acids, or as natron under the impregnation of alkaline waters, with this ſubſtance, may be eaſy of explanation; yet the preſence of vegetable alkali, which, though rarely, is ſometimes found in mineral waters, is not ſo eaſily accounted for. It has been in general referred to putrefaction; and the common methods of producing nitre favour the ſuppoſition, as well as Mr. Thouvenel's and Becher's experiments. The large collections or mines of nitre diſcovered in ſome parts of the world, as Italy, at ſome depth in the earth, although their origin is not free from ſuſpicions of miſtake, yet this circumſtance, confirmed as it is, and ſome others, might lead us to ſuppoſe nature capable of producing it in other manners.

The vegetable alkali has been found in waters within the circuit of large towns, as at Douay. Mr. Monnet relates, that he has procured it in a ſtate of conſiderable purity, united only to fixed air, from ſome of the waters of Spa, and which will appear hereafter in the analyſis of ſome of the waters near Spa. And he ſeems to think that it is more frequently to be met with in a ſtate of purity than is in general imagined. It is moſt commonly united, in mineral waters, to the nitrous acid; though inſtances occur, as will hereafter be proved, of its combination with other ſubſtances.

Alkaline waters are moſt abundant in mountainous countries, and in countries where volcano's exiſt at preſent, or have ſhewn themſelves formerly, and they are all charged with mineral alkali; alkaline, as well as ſulphureous ſprings, ariſe from deep ſources; and they are all abundantly ſtored with aerial acid, which ſhews itſelf with quick ſparklings as ſoon as ever they iſſue into the open air; this ebullition is generally a convincing proof of their alkalinity. Another teſt of the alkaline waters is the abundance of abſorbent earths they generally contain, which are united to great quantities of gaſeous ſpirit, to diſtinguiſh it from common air, which M. Venel ſuppoſed only to be contained in ſuch waters, and to which he united ſome other acid ſaline body, to account for the brilliancy in their taſte.

Nothing more remains to be ſtated in this general account, than to point out the method that is intended to be purſued in the following analyſis. The firſt and moſt obvious method of examining any mineral waters, and previous to any inveſtigation of their compoſition by the rules of art, is by their taſte and appearance in the mineral fountain; every perſon, though little converſant in medical enquiries into their nature and properties, may immediately perceive the difference of medicinal from common waters, and, at the ſame time, diſcern their greater or more remote reſemblance to other mineral fountains, with whoſe qualities he may have been previouſly acquainted, and thereby be able to arrange them under their proper claſſes.

If, on taſting any water that is new to him, it ſhall affect the organ with a lively briſk ſenſation, and on agitation, or pouring it out of one glaſs into another, it ſhould ſparkle, emit and diſcharge a number of little bubbles on the ſurface, and cover the inſide of the glaſs with a great number of ſmall air-bubbles; he may reſt aſſured, that ſuch a water is plentifully ſtored with aerial acid, which will act as a ſolvent of its contents. If, on adding to a little of this water in a glaſs a ſmall quantity of pure vegetable or fixed alkali, no ebullition or efferveſcence ſhall enſue, the exiſtence of any mineral acid in it will be rendered doubtful.

The effects of acids and alkalies, in changing the blue juice of vegetables into red or green, are ſo generally known, that it is unneceſſary to mention the diſtinction of them. The ſyrup of violets has long held a place amongſt the ſenſible teſts of acid or alkali; but Bergman is diſpoſed to reject it altogether, as it is ſubject to fermentation, and is not ſenſible of the preſence of aerial acid in water; and ſubſtitutes in its room the tincture of turnſole, which, from a perfect blue, in a dilute ſtate, will turn red, if fixed air, ſufficient to fill only one-fiftieth part of the veſſel, has paſſed through the water; or one part of water ſaturated with fixed air, will make fifty parts of the tincture of turnſole diſtinctly red. The ſyrup of violets will ſometimes turn green, when the ſubſtances contained in the water are really not alkaline. Yet the variety of chemical agents that are directed to ſimilar purpoſes, which exiſt in nature, has inclined other chemiſts to keep ſyrup of violets ſtill on the liſt of teſts, and join its uſe with the lacmoſs, a lake or pigment prepared from the *Lichenes fruticoloſi* of Linnæus, or the white moſſes that grow on the rocks in the Archipelago, Canary, and other iſlands, and in commerce it is called Archil or Orſeille.

A teſt which promiſes, in ſome caſes, to anſwer our purpoſes, under this article, better than either of the other, has been pointed out by Mr. Watt, in the juice of the red cabbage.

In the application of an agent ſo important as fixed air, to the doctrine of mineral waters, and of Spa waters in particular, the perfect knowledge of its affinities to bodies in general, and eſpecially thoſe frequently occurring in water, is of the firſt conſequence. The illuſtrious Bergman, who conſidered it as a real acid, though perhaps the weakeſt of all, has determined the relative places of different ſubſtances as affected by its attraction—and his exact table of them is therefore here ſubjoined.—Certain appearances, which might not have been expected, take place in waters abounding with fixed air, and which are worth mentioning here, as capable of leading into miſtakes. In thoſe waters in which lime, magneſia, &c. are kept in ſolution by an exceſs of acid, the ſimple addition of cauſtic alkali will throw down a precipitate of earths.

AFFINITIES OF THE AERIAL ACID.

Pure terra ponderoſa.
Lime.
Pure vegetable alkali.
Pure foſſil alkali.
Pure magneſia.
Pure volatile alkali.
Pure clay.
Calx of zinc.
Calx of iron.
Calx of manganeſe.
Calx of cobalt.
Calx of nickle.
Calx of lead.
Calx of tin.
Calx of copper.
Calx of biſmuth.

Calx of antimony.
Calx of arſenic.
Calx of mercury.
Calx of ſilver.
Calx of gold.
Calx of platina.

Water.
Spirit of wine.

The principal precipitants made uſe of were:

1. Syrup of violets, which in ſome caſes, by coincidence of facts, may give a certainty, from ſhewing properties different from other analogous teſts: and the green it will ſometimes ſhew with iron, is readily diſtinguiſhable from that produced by alkalies; and its fermentation may be readily prevented.

2. The tincture of turnſole obtained from lacmoſs.—A ſingle grain of concentrated vitriolic acid will give a viſible red to 400 cubic inches, or about 170,000 grains of this blue tincture.

And paper ſaturated with the tincture of turnſole, prepared by boiling with a little ſtarch in diſtilled water ſome of the lacmoſs being encloſed in a linen cloth, is changed with acids to a red; while alkalies reſtore the blue colour again, and heighten the original one; yet this paper is not ſo ſenſible of the agents as the tincture.

3. The watery tincture of Brazil wood, which is red, but readily becomes blue with alkalies, and paper prepared with a little ſtarch boiled in the tincture, anſwers better than the tincture itſelf. One grain of freſh chryſtallized vegetable alkali, diſſolved in

4,000

4,000 grains of water, changes the red colour of this paper to a ſenſible blue: acids change it to a yellow, and reſtore the red colour deſtroyed by the alkalies.

4. A ſaturated tincture extracted by ſpirit of wine from powdered galls.

This tincture readily diſcovers iron, and ſlowly precipitates it out of water. If the metal is in ſmall quantities, the water and precipitate become purple, through different gradations of the ſhades, in proportion to the quantity; and when it is large, they both will be black.

A ſingle drop of this tincture will give a diſtinct purple to a pint of diſtilled water, in which leſs than $\frac{1}{50}$ part of a grain of iron is diſſolved.

5. The phlogiſticated alkali. This preparation will diſcover alſo the ſmall-

eſt portion of iron. Diſtilled water, containing in a pint of it 2 grains of green vitriol, on the addition of a ſingle drop of the lixivium of phlogiſticated alkali, inſtantly ſhews a Pruſſian blue; it precipitates copper of a reddiſh colour, manganeſe white, and precipitates alſo other metals.

6. Concentrated vitriolic acid.

7. The acid of ſugar is a moſt delicate teſt to diſcover lime, however mixed; a ſingle grain of pure lime in a pint of diſtilled water, with a ſmall portion of the chryſtallized acid of ſugar, ſhews white and fleecy clouds.

8. Aerated fixed alkali precipitates all the earths and metals from their ſolutions.

9. Lime-water, dropped into water with an aerial acid in it, renders it turbid; for whatever part of the lime is

penetrated by this acid, becomes inſoluble and fouls the water.

9. Salited terra ponderoſa is of the greateſt conſequence in diſcovering the ſmalleſt traces of a vitriolic acid; as this acid will immediately form a ſpathum ponderoſum with that teſt, which will not be ſuſpended in the water; and ſuch is the ſenſibility of this teſt in diſcovering vitriolic acid, that it even exceeds the tincture of turnſole in its ſenſibility of the aerial acid.

10. Nitrated ſilver, when diſſolved in diſtilled water, will detect the ſmalleſt veſtiges of a marine acid, which will immediately ſeize on the ſilver, and form a ſalt incapable of being readily diſſolved, and therefore is ſuſpended in the water in the form of a white fleecy cloud.

11. Nitrated mercury: there are

two kinds; one made without heat, which is precipitated by the cauſtic vegetable alkali in a yellowiſh white powder, by ſal ſodæ, yellow; by all ſubſtances containing marine acid the precipitate will be in large quantities, and of a curdly ſubſiſtence: if made with heat, the marine acid is immediately detected by this ſolution; and, ſhould neither the marine or vitriolic acid be preſent in the water, the mercury is precipitated by lime, magneſia, &c. diſſolved by the aerial acid; but with new chryſtallized vegetable alkali, a ſingle drop of the ſolution forms thick ſenſible clouds in the water.

12. Corroſive ſublimate may be of uſe in the diſcovery of aerated alkali, when in a diſſolved ſtate; but a ſmall piece of the corroſive ſublimate will detect the alkali ſooner than the ſolution.

13. White arſenic can only be uſeful in waters impregnated with hepatic air, without a genuine hepar in them: wherever the hepar is genuine, the common acids will diſcover the ſulphur; and a ſmall piece of white arſenic is ſaid to have been coloured with a yellow powder reſembling ſulphur, and formed an orpiment; but I believe this experiment has not often ſucceeded.

The generality of examiners of mineral waters are abundantly furniſhed with precipitants; but for real uſe moſt of them are unneceſſary, as few can diſcover more of their true contents than the preceding ones, if judiciouſly managed; and none, I believe, will make their component parts more manifeſt, and with equal accuracy: ſuperfluous trials tend only to confuſion, and the heaping experiments upon experiments, without any apparent deſign, will tend only to perplex, rather than to convince upon any rational grounds.

The fixed acid, when properly underſtood, conſtitutes the mineral ſpirit of all the celebrated mineral waters: for, if this elaſtic fluid, that poſſeſſes all the properties of that ſubtle acid, be gradually diſſipated by expoſure to the open air, or ſuddenly diſperſed by heat, the waters will loſe all their invigorating powers, as well as their pungent taſte and ſpirit, never to be altogether recovered again, ſhould we be able, by artificial means, to recover it in part; but never, perhaps, in equal quantities, this elaſtic fluid. Analyſis thus, as well as ſyntheſis, perfectly agree on this ſubject, and ſuggeſt very powerful arguments,

guments, why ſuch naturally aerated waters can never be truly imitated by artificial means; for, though art may boaſt of giving theſe mineral waters their aerial ſpirit again in equal quantities, or to plain ſimple water as much of this mineral ſpirit as they ſuppoſe water is capable of being united with; yet experiments, founded upon true chemical principles, will hereafter prove, that ſome of the natural mineral waters of Spa do really contain greater quantities of this permanent elaſtic gas, than any artificial means, hitherto put into practice, are able to communicate to any water whatever.

The inveſtigation of the mineral properties of medicinal ſprings by analyſis, ſeems to originate from the honourable and illuſtrious Mr. Boyle.— None of the preceding writers, who have enumerated great varieties of medical fountains, as well as different common waters, and diſtinguiſhed them into hard and ſoft, warm and cold, ſaline and chalybeate, ſalubrious and poiſonous; yet the waters do not appear to have acquired theſe arbitrary denominations from the real knowledge of their contents, inveſtigated by analyſis, till Mr. Boyle had diſcovered the uſe of ſeveral precipitants; they knew, indeed, that ſyrup of violets was changed from purple to red by lemon-juice and vitriolic acid, yet the effect was referred to ſome particular properties in theſe bodies, rather than to the acid part of them in particular; and the habitude of alkaline bodies turning the blue juice of vegetables green; and he inſtances the juice of the blue-bell was firſt diſcovered by Mr. Boyle; he afterwards gives in his writings a great variety of different appearances, occaſioned by acid and alkaline ſolutions of different metallic bodies, as well as the ſimple tinctures of vegetable bodies. Du Clos attempted, in a few years after theſe diſcoveries, and at the firſt inſtitution of the royal academy at Paris, the examination of moſt of the mineral waters of France. Mr. Boyle, twenty years after this period, entered into a more accurate examination of different waters, by the uſe of a great variety of chemical combinations of different bodies. Hoffman ſeems to be the firſt that fully eſtabliſhed the fact of what the ancients called nitre, natron, or mineral alkali, exiſting in various medicated fountains. Vitriolated magneſia, then called the ſal catharticus amarus, had been in great ſame at Epſom for many years, and was afterwards diſcovered in the waters of Seidlitz, Seidſchutz, and various other waters; yet the true compoſition of this ſubſtance remained unknown till the year 1755, when the great Dr. Black, of Scotland, undertook the examination of the nature of magneſia and other calcarious ſubſtances, and laid the firſt foundations of all the great improvements in modern chemiſtry. About this time, Mr. Venel, appointed ſuperintendant of the examination of the waters in France, publiſhed his commentary on Seltzer water, in which he ſhews, that the volatile vitriolic ſpirit of Hoffman was not a true mineral ſpirit, but, on the contrary, contends that it is no other ſpirit than the air itſelf; inſomuch that he may be ſaid to have come nearer to the truth than any other preceding writer; but he never attempted to prove this elaſtic ſpirit to be a real acid, but attributes all its effects to the properties of the elaſtic fluid, common air.

In a minute inveſtigation of the properties of the beſt mineral waters, it is frequently neceſſary to collect the elaſtic vapour, more or leſs abounding in them; and this proceſs was formerly attended with great difficulty and imperfection; difficult, from the modes in uſe to collect it, as well as it was imperfect in the defect of collecting the whole of theſe vapours, or by expoſing part of them to re-abſorption. The beſt, and only certain method of collecting theſe elaſtic fluids is, by an apparatus, at this time generally well known, and to paſs them through quickſilver into an inverted veſſel of a ſuitable ſize, exactly meaſured as to its capacity, and graduated; by which means the ſpace apparently empty, but which is really occupied by theſe elaſtic vapours, may be exactly aſcertained; and, by agitating the vaporous fluid with lime-water, introduced into the veſſel, the aerial acid will be all abſorbed by the lime-water, and the common atmoſpherical air, ſhould there be any in it, remain in a ſeparate detached ſtate; and then, by deducting the quantity of the latter from the whole bulk of the elaſtic vapour collected in the veſſel, the true quantity of aerial acid evaporated from the water may be exactly known.

It may happen, that in ſome mineral waters, the phlogiſticated vitriolic acid, generally called the volatile acid of vitriol or of ſulphur, may be mixed in ſome ſmall quantity with the aerial acid, but this rarely happens to be the caſe; and I will take upon me to ſay, in the celebrated waters of Spa, whoſe penetrating and active qualities have been aſcribed to a volatile vitriolic ſpirit, that the ſmalleſt portion of ſuch an acid does not exiſt in them; and moreover, the preſence of a volatile vitriolic acid is incompatible with the real exiſtence of the aerated alkaline ſubſtances, which by analyſis are actually found in theſe waters: not to inſiſt on various other chemical reaſons of their incompatibility, had there been any real vitriolic acid in theſe waters, on the addition of ſpirit of wine, they would ſeparate their magneſia and lime completely vitriolated. — Vide Bergman's man's table, in this book, of the affinities of aerial acid.

To complete the analyſis of mineral waters, and collect the different ſubſtances held in ſolution in them, the evaporation of the water, moſt generally by ſlow degrees, becomes neceſſary; and the conduct of this proceſs in a proper manner, is of great importance in the diſcovery of their real contents. The veſſels employed in the evaporation ſhould be broad and ſhallow, as fluids evaporate more or leſs haſtily in proportion to the ſurface expoſed to the action of the open air. The ſize of the veſſels muſt be determined by the quantity of the fluid neceſſary to be evaporated, and this quantity will be regulated by the heterogeneous contents ſuppoſed to be in the mineral water; if they are abundant, leſs water will be required to form an experiment on them; when the quantity is ſmall, more water and larger veſſels will be wanted. Should the veſſels not be ſufficient to evaporate the quantity required at once, you may add more water, with caution, from time to time.—Glaſs veſſels would be beſt at all times, but are expoſed to great danger of breaking by ſudden changes of heat and cold. All the metalline ones are improper, and expoſed to corroſion. Stone ware, if ſmooth and glazed, is freeſt from any hazard of deſquamation in ſcraping off the ſubſtances that are depoſited on them, and their ſmoothneſs on the inſide ſuffers nothing to lie concealed, as in the irregularities of rougher veſſels.

Gentle methods of evaporation are beſt, to prevent decompoſition, or even diſſipation of the ingredients, occaſioned by violent ebullition; and a looſe cover ſhould be laid over the evaporating fluids.

Different appearances in the waters will come on in the different ſtages of the evaporation.

If lime and iron are preſent in it, when the quantity of aerial acid diminiſhes, as it will do in low degrees of heat, they will become no longer ſoluble, and collect together on the ſurface of the water, and form a pellicle, which, when broke by the agitation of the water in the proceſs, ſeparates into pieces, and falls to the bottom. When the pellicle is formed only of iron, it remains whole a longer time, and appears variegated with different colours, and continues ſo till all the phlogiſton of the metal is diſſipated, and the iron becomes in a calceform ſtate, and then it ſubſides; and both lime and iron will ſubſide before a boiling heat comes on. After the aerated lime and iron have ſubſided, the ſalts begin to fall, gypſum firſt, if there is any in the water. All the ſaturated ſolutions with ſaline bodies will appear in the evaporation, in the due order of their ſolubility, or ſuch as are the leaſt ſoluble in water will appear firſt, and the others in ſucceſſion, but which is frequently interrupted by the inequality of the quantities of the different ſaline ſolutions; generally the martial vitriol is next in order, and the magneſia laſt of all, or rather it will gradually fall during the whole proceſs, even to the end of the evaporation.

Theſe different heterogeneous matters may either be collected as they ſhall appear, which is preferred by ſome good chemiſts; but ſhould magneſia appear in the water, that would interfere with the propriety of this mode, which ſeems of leſs importance in general than Mr. Monnet apprehends, and on which he lays ſo much ſtreſs. The ſalts, when collected as Mr. Monnet directs, will be more or leſs united with one another, and perhaps had better be ſeparated from one another when all are united in one maſs, and the evaporation continued without any troubleſome or unneceſſary interruptions, till the whole is evaporated, by ſlow degrees, to dryneſs.

The moſt important part, in a juſt analyſis of mineral waters, is the examination of this reſiduum, and an exact eſtimation of the different ſubſtances it contains, and the quantities of each of them; being firſt duly ſeparated, to be exactly aſcertained.

The generality of modern chemiſts have ſought for certainty in the inveſtigation of the contents of mineral waters by evaporation, and a ſubſequent examination of the reſiduum. Teſts, as they are called, have been commonly conſidered as ſimply indicating the quality of the component parts, and uſed as ſerviceable auxiliaries to facilitate the examinations of them, when time and convenience for more extenſive reſearches were wanting, though, for determining proportional quantities, little advantage can be expected from them.

A more extended application of their effects, to the analyſis of mineral waters, as Bergman and Beaumé had before hinted, has however been made; M. Gioanetti applied, ſome time ago, lime-water, in a very ingenious mode, to determine, not ſimply the preſence, but the quantity of aerial acid in the waters of St. Vincent.

This phyſician, having mixed nine parts of lime-water with two parts of the waters of St. Vincent, aſcertained the exact weight of the aerated lime, formed by the ſaturation of the calcarious earth of the lime-water with the aerial acid in the mineral waters; and then calculating, after Mr. Jacquin, that 31 ounces of chalk contained 13 ounces of the acid, he determined the quantity of fixed air in a given proportion of St. Vincent's water.

Mr. Fourcroy has propoſed ſeveral objections to the accuracy of analyſis by evaporation; for he obſerves, that the heat uſed in that operation may alter the principles of the mineral waters in a ſenſible manner; and that compounds, diſſimilar to thoſe originally reſiding in them, are preſented by the reſiduum, when ſubmitted to examination. He obſerves the changes that the loſs of the elaſtic fluids, expelled by fire, muſt occaſion, and the precipitations ſubſequent to their eſcape; and, in a memoir read to the Society of Medicine, endeavours to eſtabliſh the uſe of teſts, in a pure ſtate, in the analyſis of mineral waters, in a manner more extenſive and different to what has been generally done.

He adviſes, that inſtead of the ſmall quantities of the mineral water to be tried, which are generally made uſe of, ſeveral pounds weight ſhould be taken of them, and each teſt added, till nothing further is precipitated: the precipitate being allowed ſeveral hours to collect in a cloſe veſſel, the mixture is to be filtrated, and that part of it which does not paſs the filtre, after drying and weighing, to be examined; and thus the nature of the ſubſtance, on which the teſt has acted, is to be accurately aſcertained, and the cauſe of the decompoſition determined.

Mr. Fourcroy gives the application of his principles to the analyſis of mineral waters, and deſcribes the order in which the ſeveral teſts ſhould be applied, according to their power of altering a greater or leſs number of ſubſtances, which it is not neceſſary to delineate here; but the general idea ſeems capable, in a variety of inſtances, of being applicable with great advantage.

A method of procuring the ſalts of mineral waters, without evaporation, was many years ago pointed out by Mr. Boulduc, and which, however imperfect it may be, will admit of a uſeful application.

This chemiſt relates, in the analyſis of the waters of Paſſy, near Paris, that on the affuſion of an equal weight of alcohol, the ſelenite in the water was thrown down in a chryſtalline form; that, on the addition of more alcohol, the Glauber's ſalt ſhot into chryſtals; and that, with ſtill more of this vinous ſpirit, ſea ſalt was diſcovered, and began to chryſtallize.

Theſe experiments have been applied, by ſubſequent writers, with great ſucceſs, to a ſtill greater variety of ſalts, inſoluble in ſpirit of wine, or requiring a very large quantity of that menſtruum, as the vitriolic ſalts will do; while the alcohol is alſo employed to take up from the reſiduum, after evaporation, certain muriatic and nitrous ſalts, with which it combines very readily, though in unequal quantities.

It may be neceſſary, before we cloſe this introductory part, with the account of the methods that were actually taken in forming the following analyſis of the mineral waters which were ſelected for that purpoſe; and which method was inſtituted on the compariſon of the difrent modes of analyſis that were undertaken, and recommended to others, by the beſt chemiſts of the age, for this purpoſe; and, by the reconciliation of their various and different directions to the true principles of cheміſtry, the beſt ſuppoſed poſſible mode was formed of treating the different ſubſtances that were found in the different *reſidua* of the waters, in order to aſcertain the exact quantities of each, and of what combined ſubſtances the component parts of the reſidua were ſeverally formed;—it may be neceſſary, I ſay, to attend to the great variety of the different ſubſtances that are actually and generally found in water.

Very minute particles of flint, lime, magneſia, and clay, are ſaid, by Mr. Bergman, to be found mechanically ſuſpended in water. A curious queſtion might here ariſe, How far the action of fixed air in water may be extended, in regard to different earths?—and, Whether the common idea, here expreſſed by this great chemiſt, of the ſuſpenſion of many different bodies in water, by mere mechanical action, was altogether juſt and true?

The union of fixed air with clay has been demonſtrated by Mr. Schreiber, and ſince by another good chemiſt and ingenious phyſician, the account of which is not given to the public; perhaps the exceſs of aerial acid in water may, in certain circumſtances, act on argillaceous earths in the ſame manner as on other earths. A variety of arguments have been made uſe of to ſhew that ſiliceous earths are inſoluble in water, either pure or ſaturated with fixed air. The appearances of water, &c. in the internal parts of quartz chryſtals, would ſeem to point out an aqueous origin to thoſe bodies; and ſome obſervations of Sauſſure and

Bartolozzi ſeem to confirm the ſuppoſition.

Though water, ſaturated with fixed air, was unable, in Bergman's experiments, to take up quartz; and though we ſhould not be diſpoſed to allow thoſe of Mr. Achard to be deciſive; yet ſome later reſearches of Mr. Morveau ſeem to point out inferences in favour of the action of fixed air. In the experiments of this moſt excellent chemiſt, water, loaded with fixed air, had, after a very conſiderable time, a perceptible operation on the quartz; and from that water a chryſtal of the form and nature of real quartz was produced.

Aerial acid is abſorbed by all water, but in ſuch unequal quantities, that the proportion of it in different waters will be from $\frac{1}{100}$ part of their bulk, to a bulk, when ſet at liberty, exceeding that of the water itſelf. This, as well as pure air, contained alſo in many waters, occaſions the bubbles that appear on the firſt impreſſion of the heat; and, in proportion as the aerial acid is diſengaged, the pellicle and the depoſition is formed, which ariſes from calcarious earth and aerated iron. Inflammable air is found to paſs through ſome waters, and expand on the ſurface; vegetable alkali is oftener found in waters than has been apprehended by the firſt chemiſts; mineral alkali, however, often occurs, aerated, vitriolated, or ſalited.

It has been before ſaid how volatile alkalies are combined with water, and in a mode different from the decompoſition of animal and vegetable ſubſtances.

Terra ponderoſa may accidentally appear in it, united with the marine acid.

Lime very frequently, and oftener than magneſia, and both aerated, vitriolated, nitrated, or ſalited.

Though vitriolated clay, or alum, is ſeldom found, yet it has been diſcovered, as was mentioned before, by an ingenious phyſician, muriated or ſalited, as well as aerated, in Nevil Holt water. Iron, of all the metals, is moſt frequently found in mineral waters, moſt commonly aerated, not unfrequently vitriolated, and may perhaps be found ſalited. Manganeſe, copper, and arſenic, very rarely occur in it, as the ſubject is confined to particular objects. Snow, rain, and ſpring waters, as well as river, well, and marſh waters, together with ſea water, are here paſſed over.

Mr. Venel and Bergman, apprehenſive that great degrees of heat might alter the nature of the fixed principles in waters, direct the heat to be employed in evaporation to be continued below the boiling point. Mr. Monnet, to prevent by its motion the admiſſion of any foreign ſubſtances, chooſes to boil the water. Mr. Bergman's method of evaporation was preferred, except in making a hole in the lid of the covering to give paſſage to the vapours as they ariſe, which retarded the operation, and a looſe cover applied in the beginning became unneceſſary, when the increaſe of the heat towards boiling diſperſed the vapours ſufficiently to prevent the admiſſion of foreign ſubſtances: and Mr. Bergman's method of gentle evaporation to dryneſs was purſued: but the confirmation of the analytic part by ſyntheſis was not minutely attended to in the whole of the proceſſes.

The uſe of hepar ſulphuris, as a precipitate, recommended by many writers, will be more particularly attended to when the ſulphureous waters of Aix become the ſubject of enquiry. —Alcohol, added in ſufficient quantity, precipitates all the ſalts found in waters which are inſoluble in ſpirit of wine; and on experiment it will be found to take up from $\frac{1}{7}$ to $\frac{1}{10}$ of its own weight of different nitrated and ſalited bodies.

The evaporation being continued to dryneſs; and in every evaporation which I made for experiments on the reſidua, upon which I could depend, I generally employed a conſiderable quantity of the mineral water, ſeldom leſs than two gallons ; the whole reſiduum was then carefully collected and weighed. In the conduct of the evaporation, the chryſtallization of the ſelinite, if there is any in the water, will ſucceed the firſt pellicles, and laſtly the marine ſalt, if any in the water, and mineral alkali, and form cubic chryſtals ; the deliqueſcent ſalts can only be found by conducting the evaporation to dryneſs.

1. The whole reſiduum was then well dried, and put into a bottle, and alkohol pour'd over it to the height of an inch : the veſſel was well ſhaken, and ſhut cloſe up ; and after ſtanding ſome hours the liquor was filtered.

2. To the reſiduum, eight times as much cold diſtilled water was added : it was again ſhaken, and after ſome time filtered alſo.

3. The reſiduum was then boiled a ſhort time in a large quantity of diſtilled water, and filtered again.

4. And laſtly, the reſiduum that now remained was not ſoluble in either water or ſpirit of wine.

The preſence of iron in the reſiduum will give a manifeſt browniſh ochrous colour to it: by expoſing it in the rays of the ſun for ſome time, the metal will become ſo far dephlogiſticated as not to be diſſolved in vinegar; and then, by pouring diſtilled vinegar upon it, the aerated lime and magneſia, which remain in it, will be diſſolved; what little of it may then remain, when waſhed and dried, will ſhew by the loſs of its weight how much has been diſſolved by the vinegar.

The acetous ſolution is to be evaporated to dryneſs: if it yields a filamentous

mentous ſubſtance, which remains unaffected in a moiſt atmoſphere, it is lime; but becomes deliqueſcent if it contains magneſia. A diluted weak vitriolic acid will form out of this maſs a vitriolated magneſia, like Epſom ſalt, that will chryſtallize; and if the baſe is compoſed of both lime and magneſia, it will form both gypſum and vitriolated magneſia.

If we refer to the chemical compoſition of gypſum and vitriolated magneſia, as eſtabliſhed by numerous experiments, the exact quantity of each of theſe ſubſtances will be readily aſcertained. The part that remains inſoluble in the vinegar muſt be either argillaceous, martial, or ſiliceous earths: the preſence of the firſt will be determined by the turbid colour it gives to water; and the two firſt are both ſoluble in marine acid, and both to be precipitated by phlogiſticated or plain alkali. The ſiliceous earth will remain inſoluble in the marine acid, and may be aſcertained by the blow-pipe.

Nothing now remains for further examination but the four ſubſtances, in the order of them reverſed.

1ſt. The reſiduum inſoluble in the ſpirit of wine, and water of different temperatures; 2d. The reſiduum taken by the boiling water, and 3dly, by the cold diſtilled water; and 4thly, The ſalts diſſolved in the ſpirit of wine.

The reſiduum inſoluble in the ſpirit of wine, or in water of different temperatures, has been already treated with vinegar, and the reſults of the ſolution explained.

The examination of the contents reſulting from cold diſtilled water, in the proportion of eight parts of the water to one of its contents, requires the greateſt attention. The water holds the neutral ſalts in ſolution; marine ſalt, Epſom ſalts, and aerated foſſil alkali, are common in waters; Glauber's ſalt, the febrifugal ſalt, or ſal ſylvii, and vitriolated tartar, are more rare. Alum was long ſuſpected by the earlier chemiſts to be one of the moſt general agents in the formation of mineral waters; this opinion, which was only conjectural, experiment has exploded, and it has been found that alum is a rare ingredient in their compoſition. The analyſis of the waters of Dominique de Vals, yielded alum to Mr. Mitouart: and the ſame ſubſtance was detected by Mr. Opoix in thoſe of Provins. Marine alum enters into the compoſition of ſome waters, as thoſe of Nevil Holt, which baffled the penetration of former chemiſts; but it is to be hoped, that a matter ſo long deemed problematical will ſoon, by the diſcovery that the ingenious author has made of a ſalited clay in their compoſition, when his analyſis is given to the public, throw much light on the nature of thoſe truly uſeful waters.

The nature of the ſalts contained in ſolution is beſt diſcovered by a ſlow evaporation. When only one kind of ſalt is contained in the water of it, after its action on the reſiduum, the obtaining it by chryſtallization is ſufficiently eaſy, as well as thereby to aſcertain its nature. But it happens moſt commonly that ſeveral kinds of ſalts are preſent together in the ſolution: excepting common ſalt, all the different ſalts may be made to aſſume their regular chryſtals, when the evaporation is carried on in a heat, by Fahrenheit's thermometer, from 176 to 196, till a drop of the ſolution, let fall on a cold glaſs, ſhews the appearance of ſpiculæ.

When the figure of the ſalts is not the object of examination, but the ſpecies of them, other methods will be pointed out.

The chryſtals which ſucceſſively appear, being collected together, and dried on blotting paper, in ſuch a manner as not to expel the water of chryſtallization, the proper nature of each ſalt may be examined according to their habits, form, taſte, &c.

The alkaline ſalts are to be aſcertained by the various precipitants, taſte, habits with acids, &c.; and diſtilled vinegar will readily diſcover whether the alkali is foſſil or vegetable, forming with the firſt a foliated chryſtallizable ſalt, and with the other a deliqueſcent one.

The ſalts compoſed of an acid, united to an alkaline, earthy, or metallic baſe, are to be inveſtigated with a ſeparate attention to,

1ſt. Their acid.

2dly. Its baſe.

The combination formed by the union of vitriolic acid with the mineral alkali, agrees in ſome particulars with the ſalt reſulting from the union of magneſia with this acid; their general properties are however widely different, and an eaſy method of diſtinction is afforded by lime-water. A chryſtal of each ſalt being added to lime-water, the fluid is not rendered turbid by the Glauber ſalt, but the vitriolated magneſia is decompoſed, and the acid uniting with the lime falls to the bottom in the form of gypſum, together with the deſerted magneſia.

The marine acid, when combining with foſſil or vegetable alkali, yields ſalts agreeing in many properties, as being cubic, decrepitating in the fire, and in having a taſte ſomething ſimilar. A mode of diſtinguiſhing the baſe in theſe two combinations has been found in the acid of tartar, which, dropped into a ſolution of the ſalt of Sylvius, or vegetable alkali united with marine acid, called alſo digeſtive ſalt, precipitates a true tartar; while a ſolution of common ſalt is not acted upon in the ſame manner.

The nitrious and marine acid will alſo be noticed hereafter, in the examination of the ſolutions in alcohol.

The more obvious methods of diſtinguiſhing thoſe various ſalts that may be mixed in the ſolution of the reſiduum by cold diſtilled water, are too generally underſtood to require a particular diſcrimination in this place. Perfect neutral ſalts are compoſed of acid and alkali, the middle neutral ones have not a ſaline but an earthy or metallic baſe. The ſubſtances taken up by ſpirit of wine will not preſent any great variety; muriated terra ponderoſa, muriated lime and magneſia, and nitrated lime and magneſia, are thoſe which when preſent in the reſiduum are commonly held in ſolution in the alcohol. The proceſs directed by Bergman, of evaporating to dryneſs, and afterwards treating the reſiduum with diluted vitriolic acid, though well adapted to the diſcovery of the baſes, is hardly adequate to the determination of the compoſition of the acids.

The acids united to the earths are found by the application of a ſtrong concentrated vitriolic acid, a few drops of which diſengage marine gas, if preſent, known by its ſmell and white vapour; the peculiar odour and red ſmoke of the nitrous are ſufficient to mark its eſcape: when very ſmall quantities are preſent, or greater accuracy is required, a paper, moiſtened with volatile alkali, expoſed to the fume, will render manifeſt the ſmalleſt trace of nitrous acid; and a wetted paper any veſtige of the marine acid. Farther modes of detecting theſe acids are abundantly furniſhed by modern chemiſtry.

The abſolute WEIGHT of 100 Cubic Inches of the different AIRS, as well as their Proportion to Common Air, are thus ſtated by Mr. KIRWAN.

	Abſolute Weight.	Proportion to Common Air.
Common air —	31. Gr.	1000
Pure air — —	34. —	1100
Phlogiſticated air —	30.535	985
Nitrous — —	37. —	1194
Vitriolic — —	70.215	2265
Fixed air — —	46.500	1500
Hepatic — —	34.286	1106
Alkaline — —	18.160	600
Inflammable —	2.130	84.3

A TABLE of the comparative HEATS of ſome different Bodies belonging to the Subjects herein diſcuſſed; extracted from the general Table conſtructed by Dr. CRAWFORD.

1.	Inflammable Air	21.4000
2.	Pure air	4.7490
3.	Atmoſpherical Air	1.7900
4.	Aqueous Vapour	1.5500
5.	Fixed Air	1.0454
6.	Water	1.0000
7.	Phlogiſticated Air	0.7938
8.	Alcohol	0.6021
9.	Vitriolic Acid	.4290
10.	Charcoal	.2631
11.	Quick Lime	.2229
12.	Pit Coal	.2777
13.	Chalk	.2564
14.	Ruſt of Iron	.2500
15.	———— freed from Air	.1666
16.	Iron	.1269
17.	Braſs	.1123
18.	Copper	.1111
19.	Tin	.0704
20.	Lead	.0352

THE

THE MINERAL WATERS OF SPA.

IT will be foreign to the deſign of ſuch an eſſay as the preſent one, to enter into a diſcuſſion of the chemical difference between mixture, diffuſion, and ſolution; yet it may be neceſſary to aſcertain our terms ſo far, as to limit the impregnation of any mineral water with a foſſil body, of whatever kind it may be, to a perfect ſolution of it in the aqueous fluid, and that the latter ſhall remain clear, pellucid, and tranſparent.

The general ſolvents of all the foſſil bodies, with which the various mineral waters have been ſuppoſed to have been impregnated, have, by the different writers upon them, been derived from the various acids and acid ſalts hitherto clearly aſcertained, and other acid ſaline bodies perhaps not ſo fully underſtood; from the alkalies and the various alkaline ſaline bodies and earths properly combined; and the neutral ſalts, compoſed of both acids and alkalies, under different combinations.—Now, as all ſaline bodies admit of a ready ſolubility in water, theſe different acids and alkalies, with the various ſaline bodies, were ſuppoſed to be in a proper ſtate to act on the different foſſil bodies, metals, as well as every other kind of foſſils, by reducing them into a ſaline ſtate, and render them alſo diſſoluble in the aqueous fluid; but the moſt important impregnation of mineral waters, and which gives to all mineral waters, into whoſe compoſition it enters, the moſt uſeful part of them for medicinal purpoſes, is derived from the aerial acid, that forms both fixible and mephitic airs, and which, being intimately diffuſed through the aqueous fluid, renders it capable of diſſolving any other foreign ſubſtances that may, by the means of this acid, be combined with water; for, from its fugitive nature, it has been ſaid to be rather intimately diffuſed through, than chemically diſſolved in the water.

So much has been already ſaid, in the Introduction, on this aerial acid, that it will be unneceſſary to enter into any farther account of it, than barely to advert to ſome particulars that have been advanced in medical hiſtories relating to Spa waters, and many other mineral waters that may be arranged under the ſame claſs.

The exiſtence of this aerial acid in a great variety of mineral waters, and in great abundance in the waters of Spa and Pyrmont, and many other ferruginous waters in particular, and united with alkaline earths and foſſil alkali in many of them, has occaſioned great miſtakes and perplexity in the generality of writers on theſe ſubjects; who, being under the inveterate prejudice of the knowledge then prevailing, could not be induced to ſuppoſe, that iron could be diſſolved in water, but through the ſolvent powers of a vitriolic acid, notwithſtanding theſe waters contained, at the ſame time, either an abſorbent earth or a mineral alkali, and many of them both theſe or other alkaline bodies; and this led Hoffman to give a different modification to this ſuppoſed vitriolic acid, imagining the acid in them ſtill to be of the mineral claſs, but of a nature different from what is generally ſtyled vitriolic, and of a nature too ſo volatile, that it always diſperſed itſelf on any attempts to collect it, as if its volatility diſpoſed it to unite itſelf and fly off with a metallic ſubſtance, rather than with the abſorbent earth or the mineral alkali.

This difficulty was ſuppoſed by ſome French writers to be more readily got rid of by advancing, that the vitriolic acid could not be obtained from theſe waters, through the decompoſition of the acid by the abſorbent earth or the mineral alkali, at the very time that they were ſubmitted to the experiment, and notwithſtanding the univerſality of this prejudice in favour of the vitriolic acid exiſting in all theſe ferruginous waters, and which were from thence, as well as their taſte, called aquæ acidulæ.—True vitriolic waters were very rarely to be met with at the ſame time, whereas ſuch waters, impregnated with the aerial acid, were very common.—The ſingular inſtance of the mineral waters of Paſſy, in the vicinity of Paris, being real vitriolic waters, and their ſituation ſubjecting them to frequent examinations by the learned members of the academy, contributed greatly to confirm moſt of the writers on theſe ſubjects of the French nation, till within the laſt twenty years, in their prejudices, as they made the mineral waters of Paſſy the ſubject of their comparing other ferruginous waters with them, in order to judge of their comparative merits with thoſe at their own door.

After the long account given in the Introduction of the principal agents in the formation of mineral waters, and their effects in diſſolving and otherways adapting the ſeveral component parts for medical purpoſes, nothing more can appear neceſſary to be ſaid, preparatory to entering on the analyſis of the ſeveral mineral waters in and near Spa, in the marquiſate of Frunchiment, a territory belonging to the prince biſhop of Liege, than barely to vindicate the propriety of the method of proceeding in the future analyſis of the different mineral waters herein undertaken, and to give a ſhort deſcriptive account of the country about Spa, the particular ſituations of the different fountains, of the mountains ſurrounding the place, their perpendicular heights, and of what different ſubſtances they are compoſed, as well as the different elevations of the fountains which iſſue out of them.—When I aſſure my readers, that I have attentively conſidered all the various modes of proceeding, in order to form a juſt analyſis of any mineral water, which have been propoſed by the firſt chemiſts of the age, and of every different nation in Europe where the ſcience has been moſt cultivated; compared the accounts that each has given of his own mode, with the accounts of all the others; and endeavoured to reconcile every ſeeming oppoſition in their meaſures to the ſtandard of true chemiſtry, as far as I was able, and on this baſis have raiſed the ſuperſtructure of my own; I may flatter myſelf that I have, on theſe firm grounds, attained to the end propoſed, much to my own ſatisfaction; and if it ſhall appear equally convincing and definitive to them, I ſhall hope, that the method of treatment of the waters, with the ſeveral teſts made uſe of, and the modes of treating the ſeveral component parts of the different reſidua, will be ſufficiently juſtified in the opinion of the public.

The town of Spa is ſituated at the extremity of a winding valley, on the banks of a rapid rivulet, and is well ſheltered by an adjoining hill to the north, and a high ridge of mountains encircling it, at the diſtance of a mile to two miles and a half, from the ſouth-eaſt quite round to the north-weſt.

The author of this eſſay, when he was at Spa laſt ſummer, employed ſome

of

of the beſt *geometres* and *arpenteurs*, as they ſtyle themſelves, of the place, and the adjoining villages, he could find, to take an actual ſurvey of the town and neighbourhood, in hopes, that ſuch a diſtinct plan of the country would give more preciſe and diſtinct knowledge of the relative natures of the different fountains ſituated in ſuch various aſpects, and iſſuing out of ſuch different ſtrata of foſſil bodies, than could be learned by bare verbal deſcription only; and he obtained from theſe ſkilful hands, a correct and finiſhed drawing, or carte topographique de Spa, & les environs; they took exact menſurations of the perpendicular heights of the mountains, and the different elevations of the fountains iſſuing out of the ſides of them, under his own inſpection, and which drawing he brought with him to

London, and has had it engraved by the beſt artiſts belonging to Mr. Faden, near Charing-Croſs, geographer to the King.

From this chart it may be obſerved, that only one of the Spa fountains, the Pouhon ſpring, ſituated nearly in the center of the town of Spa, riſes from the hill to the north of the town, and cloſe adjoining to it; a hill that conſiſts of argillaceous ſchiſts, looſe argillaceous ſubſtances, and earths mixed with ferruginous ſlate, in large maſſes; whereas all the other ſeven fountains have a northern aſpect, riſe on that ſide of the encircling ridge of mountains to the ſouth-eaſt, ſouth, weſt, and north-weſt, from the town; and this ridge of mountains is formed, in large maſſes, of calcarious ſtones, and marbles, and other mineral bodies, mixed with looſe ſiliceous earths and ſtones, and whoſe tops are covered with woods, interſperſed with large boggy ſwamps, filled with water and mud, which are called in the country Les Fanges.

Medicinal ſprings are found not only in the neighbourhood of Spa, but alſo in the adjoining diſtricts of Malmendy and Stavelot, of which notice will occaſionally be taken hereafter.

The moſt diſtinguiſhed mineral fountains, within the diſtrict of Spa, are,

1ſt. The Pouhon, in the center of the town of Spa.

2d. Geronſtere.

3d. Sauviniere, and 4th, Groiſbeeck, nearly together: And,

5th. The Tonnelet.

To which may be added the leſs frequented ſprings of

6th. Niverſet.
7th. The Watroz: And,
8. The Bariſart.

The neareſt of the other ſeven fountains, in the neighbourhood of Spa, is diſtant from the Pouhon more than an Engliſh meaſured mile.

As the ſituation of the town of Spa is in the loweſt part of the valley, north of the higher ridge of the mountains towards the ſouth, the cellars of the houſes near to the Pouhon, and to the north of it, have frequently much water in them, and which, on a ſlight examination, appeared ſimilar to that in the Pouhon fountain: all this ſuperfluous water, as well as the medicinal water in the well, is derived from the adjoining hill, called Annette and Lubin, from a cottage or cottages on its ſubmit, where, ſince the publica-

tion

tion of M. Marmontel's tale on the imaginary ſubject of their loves, they have been whimſically reported to have lived.

When the Grand Hotel in Spa, very near to the bottom of this hill, was built, a few years ago, the architect, to ſecure the cellars from the influx of the water flowing from under it, attempted to ſink a deep drain the whole length, and behind the building, in hopes of carrying it off by thoſe means; but, before the completion of the drain, and when only part of it was carried to its intended depth, to the great alarm and confuſion of the inhabitants, their favourite and moſt important ſource of their wealth and ſupport was found quite empty in the morning: for it is the cuſtom of the place to let all the water out of this fountain,

tain, and clean it, every night: and they ran, in great bodies, to the place where theſe deſtructive projects were carrying on, and inſiſted on having as much of the drain as was already dug out, immediately filled up again. When this was accompliſhed, to their great joy and comfort, the water happily returned to its accuſtomed courſe, and, on the ſucceeding day, the well was found full again, and the mineral qualities of the water to be not in the leaſt degree impaired. This fact was confimed to me upon the moſt creditable information, ſince ſeveral of the gentlemen, who gave me the intelligence, have annually viſited theſe medicinal fountains.

The following are the particular relations of the different elevations, and perpendicular heights of the ſeveral fountains, in the neighbourhood of Spa, above the level of the water in the Pouhon fountain:

	Perp. Heights.
Geronſtere fountain -	580 feet.
Sauviniere and Groiſbeeck f. - -	490
Tonnelet, f. - -	260
Niverſet f. - -	240
Watroz f. - -	220
Bariſart f. - -	300
The hill, called Annette and Lubin,	180

Beyond the elevations and heights of the fountains Geronſtere and Sauviniere, the mountains riſe much higher, even to the perpendicular height of 1200 feet above the level of the Pouhon; theſe heights are covered with woods and thick covers, interſperſed with large ſwamps and moraſſy grounds.

The Pouhon fountain is to be regarded as the principal ſpring at Spa, both as it is moſt abundant and powerful in the quantity as well as the quality of its iron, and as it retains, longer than any of the other ſprings, its ſpirituous gas, and of conſequence its iron alſo. The other fountains differ from the Pouhon in their general contents, as they all have leſs ſpirituous gas, except the Tonnelet, which contains it in greater abundance than any of them, even the Pouhon; and they all contain leſs iron, and in part a different kind of abſorbent earth. The Tonnelet is much purer than the others, and is impregnated with leſs of the other contents, as well as iron, than any of the others; and its elaſtic gas is more volatile and fugacious than that of all the others.

The Gerónſtere fountain is ſtill more ſingular, as it is the only one of them that ſenſibly diſcovers any hepatic air to be contained in it. The Groiſbeeck fountain has been celebrated, through a long ſucceſſion of years, for its good effects in the relief of diſorders ariſing from calculous concretions in the kidneys or bladder of urine: and a ſingular inſcription upon it records the cure of a German baron, in the middle of the laſt century, in a ſimilar caſe as is ſuppoſed; in remembrance of which, the fountain is called by his title of Groiſbeeck; and that his deſcendants erected the ſtructure that encloſes the ſpring, in gratitude for the extraordinary cure their anceſtor had received through the uſe of this water.

The Pouhon water, as was before ſaid, preſerves its ſpirituous gas much longer than any of the other waters here, and much longer than the generality of gaſeous ferruginous waters in common do. And, as the aerial acid remains ſo long tenaciouſly united to the iron, after expoſing them for a conſiderable time in a ſhallow veſſel to the open air, although the gas appears, by the loſs of the quick lively taſte in the water, by degrees to eſcape, it will be ſome time longer before the iron will begin to precipitate, and that very ſlowly, ſo perfect is the union of the iron with the aerial acid in this water.

And both theſe circumſtances contribute to render this chalybeate water ſo capable of being ſent to great diſtances from the fountain, and by proper management to be kept in high preſervation for many years. The reverſe of all this will be found to be the caſe with moſt of the other waters near Spa, but particularly ſo with the water of the Tonnelet, which may almoſt be deemed a ſimple gaſeous water; ſo ſmall is the quantity of any foſſil body held in ſuſpenſion by the aerial acid in it, and ſo fugitive is the aerial gas, that it begins to paſs off, and very rapidly, the moment it is taken out of the well, and will all eſcape in a very ſhort time.

A few grains of a pure fixed alkali, diſſolved in any of theſe waters of Spa, either abſorbs it, or quickens the rapidity with which the aerial acid eſcapes from them, and ſo far deſtroys their quick lively taſte, that they ſoon become as inſipid as common water, with the additional

ditional nauſeous taſte of the alkali; and on adding to them afterwards ſome drops of vitriolic acid, more than will ſerve to neutralize the alkali put into them, they again ſeem, in ſome degree, to acquire a ſpirituous taſte: and it was this renovation of their ſpirit, in ſome meaſure, that might perhaps contribute to minds prejudiced in favour of this acid originally exiſting in theſe waters, in confirming them more ſtrongly in this their error; for, when it was found by real experiment, that a few drops of vitriolic acid would reſtore the ſpirituous taſte, when it was once loſt, to theſe waters, it was natural to ſuppoſe that they were originally endowed with the ſame ſpirit, by the ſame combination of abſorbent earth or alkali with the mineral acid, in the bowels of the earth: without conſidering that this renewal of their ſpirit was owing to a new combination of this acid with the alkaline bodies, deſerted through the volatility of their own, the aerial one.

Every chemiſt knows, that the union of mineral acid with alkaline earths, produces great quantity of aerial acid; which, poſſeſſing a pungent but agreeable aceſcent flavour, gave to the Spa waters the name of acidulous, as well as to many others, from very early times: the propriety of which name, in the ſenſe as containing a mineral acid, may with juſtice be called in queſtion; for all the waters of Spa efferveſce with acids; and all the waters of Spa change the ſyrup of violets green when they are in perfection: both theſe circumſtances are certain proofs of an uncombined alkali being originally in them. Alkaline ſubſtances, whether ſaline or earthy, tho' ſaturated with aerial acid, ſtill act as precipitants in conſequence of their alkaline nature; and the force which they exert is not changed by the aerial acid, on account of its extreme weakneſs; for aerial acid cannot efferveſce with alkalies, for whenever any efferveſcence ſhall appear, it is occaſioned by the expulſion of the aerial acid itſelf, by the addition of a ſtronger acid, and which occaſions the ſpumeſcence, and cannot ariſe from the union of an alkali with the aerial acid only.

In ſuch gaſeous acidulous waters the alkali is not only ſaturated with aerial acid, but they contain this acid in ſo copious a manner, as to render the ſubtle tincture of turnſole red, though the contrary appearance takes place with the beſt ſyrup of violets, yet the waters with propriety are not deemed truly alkaline: this acid, though abundant in all theſe waters of Spa, is not able totally to repreſs their alkaline properties, but it is alſo extremely volatile; but in chemical ſtrictneſs, neither the weakneſs nor the volatility of the aerial acid can ſubvert its eſſential properties.

Every chemiſt, well informed of the nature of phlogiſticated vitriolic acid, will be able to diſtinguiſh it immediately from aerial acid: in ſmell, the former is pungent, penetrating, the aerial one hardly ſenſible: in taſte, the phlogiſticated vitriolic acid is acrid and nauſeous; the latter is mild, pleaſant, and refreſhing: the firſt may be reduced to a liquid form, this always remains in the ſtate of vapour. The vitriolic one will ever, through its ſuperior ſtrength, expel the weaker acid from every kind of baſe with which it may be united; and the compounds of every ſpecies will every way differ from thoſe formed by the union with aerial acid.—Vide the Table of its Affinities.

So much having been already ſaid on the general principles of this important part of the mineral waters of Spa, it may be proper, before we proceed with the precipitants, and enter on the analyſis of them by evaporation, to eſtimate, by a proper train of experiments, the quantity of this ſubtle fluid which enters into the compoſition, on the ſpot, of each of the principal ſprings at Spa; and then to point out in what manner, under proper regulations, the quantity of it might either be increaſed, as well as the efficacy of its powers; or at leaſt to ſhew in what manner ſo uſeful a part of them might be detained longer in action upon the other parts of their compoſition, whereby the ſeveral ſubſtances held in ſolution by the means of this acid would be alſo encreaſed, or by proper conſtructions of the buildings incloſing the fountains, the degrees of preſſure would be advanced, and leſs of this volatile elaſtic vapour would eſcape, and conſequently leſs of the other contents would be precipitated from the body of the water to the bottom of the well, before they are adminiſtered to the invalids that reſort from all parts of Europe to Spa, for the benefit of theſe ſalutary waters.

The methods purſued, in order to collect the different proportions of the aerial acid contained in ſeveral of the principal ſprings in or near Spa, was to fill a glaſs veſſel of a proper conſtruction with each of the different waters; (this veſſel contained from 32 to 33 ounces of each; for they are not all of an equal weight, but are all of different ſpecific gravities, and thoſe too very variable in different ſtates of the atmoſphere;) and then to ſet this veſſel in a *balneum mariæ*, as it is called: and, by means of a glaſs tube properly bent, one end of which was ground, and luted alſo into the top of the firſt-mentioned glaſs veſſel, the other end of which was paſſed into another glaſs of a proper ſize inverted, and which when full up to the top, in that poſition of it, contained between 60 and 70 pounds of purified quickſilver; and, when ſeveral fine and dry days had preceded, this apparatus was carried to the ſeveral fountains, in order to make the ſeveral proceſſes on the ſide of each ſpring, at a time when the waters were ſuppoſed, with juſtice, to be in their higheſt degree of perfection: and every proceſs was repeated three, four, nay, five times, whenever any little interruption happened in any of the preceding proceſſes, at each fountain. The following table of the different reſults with each, is eſtimated by taking the medium of each ſet of experiments at each of the ſprings.

The water-bath was always quite cold, when the glaſs veſſel that contained the mineral was firſt immerſed into it; the heat was then given it by ſlow degrees; till, towards the end of the proceſs, it was raiſed to boiling, which was continued as long as there remained any appearance of the gas paſſing through the mercury, and ſinking it lower down in the inverted glaſs veſſel *; and, in order to exclude as much as poſſible the common or atmoſpherical air, the glaſs veſſel that held the mineral water was filled up to the top, leaving only room for the ground end of the bent glaſs to be inſerted.

The gas that was carefully collected in theſe ſeveral experiments, in the upper part of the inverted glaſs veſſel, was, by the means of another glaſs tube, paſſed from thence through a proper quantity, rather more than a quart, nearly three pints, of lime-water, contained in another inverted glaſs veſſel; the account of this latter part of

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* When theſe experiments were made at the Tonnelet fountain, Fahrenheit's thermometer, immerſed in the fountain, uſually ſtood at 50 degrees; in the other fountains from 47 to 48.

the proceſs will be minutely given, after the inſertion of the table of different portions of this aerial elaſtic fluid contained in the ſeveral mineral waters on which theſe numerous experiments were made.

A TABLE of the different proportions of Gas, in the ſeveral mineral waters here mentioned.

Mineral Water.	Ounces of Water.	Ounce meaſures of Gas.
Pouhon water	33.	35.75
Geronſtere	32.75	24.75
Sauviniere	32.50	33.50
Groiſbeeck	32.25	35.50
Tonnelet	32.20	40.75

It has already been obſerved, that the gas began to paſs from the Tonnelet water, the moment it was taken from the fountain, and indeed it paſſed rapidly when the veſſel was ſet in the water-bath, before it received any heat; and if a proportionable allowance ſhould be made for what thus haſtily eſcaped, although the apparatus was placed cloſe to the well, the proportion of permanent elaſtic gas in this celebrated ſpring might be ſuppoſed to be higher than 41 ounce meaſures.

In order to aſcertain the quality of this elaſtic fluid, ſeparated, in the ſeveral proceſſes, from the different mineral ſprings, the only teſts that were made uſe of, in theſe different ſets of experiments (and in which the author of this analyſis had great aſſiſtance from the abilities and induſtry of his learned and amiable friend, the reverend Mr. Graydon, of Ireland) were *lime-water* and *nitrous air*.

In its firſt ſtate, as it paſſed, none of theſe different gaſes ſuffered any change from the *nitrous air*, but all of them changed the lime from a browniſh hue to a milky whiteneſs, and quickly precipitated the lime, and the gaſes were all abſorbed by it to a 70 or 80th part; this reſiduum was found to efferveſce with the nitrous air in the ſame manner, and ſuffered an equal diminution, as with atmoſpherical air; and it was perhaps no other fluid than a ſmall portion of common air, that occupied the vacant ſpace of the tube at the commencement of each ſeveral proceſs.

The gas began to paſs from the Sauviniere water, when the water-bath was heated to about - 80 degrees.
From the Pouhon and Groiſbeeck - - 90
From the Geronſtere, not till - - 110 or 120

The rapidity of its paſſage from the Tonnelet water has been before noticed.

The civil and worthy Mr. Briart, who lives at the Tonnelet fountain, as well as his excellent brother, now an apothecary of character at Spa, relate ſeveral particular circumſtances of this mineral water, of their perſonal knowledge. A very ſingular one, relative to it, I ſhall beg to relate from their information.

Every attentive obſerver of this fountain on the ſpot, muſt take notice, in what greater abundance the air paſſes through the fountain than in any of the others at Spa, and in what profuſion it bubbles up through the water.

They informed me, that on any ſudden or extraordinary changes in the weather, the quantity of air that bubbles up is remarkably increaſed; and that at theſe ſeaſons the cellars of their own houſe, and of the adjoining houſes, that lie in the direction of the ſource, are filled with gas to ſuch a degree as to become ſo many *grottos del cani*; ſo much ſo, that the domeſtic animals learn by experience to dread them when they are in that ſtate. From theſe repeated obſervations, the peaſants in the neighbourhood of the fountain have drawn an uncommon weather prognoſtic; conſtantly expecting bad weather in their harveſt-times, whenever they find that their cats expreſs reluctance, and even reſiſtance, againſt being carried into their cellars; which they always will do whenever the fixed air is abundant in them.

Mr. Briart, who has a perfect command of this water, and can have any quantity of it that he chooſes (for there are four diſtinct fountains on the ſpot, very contiguous to each other, and very ſimilar in their powers) was induced, ſome years ago, on the perſuaſions of a medical gentleman, to conſtruct a large bath of theſe waters for the purpoſes of bathing; but the water is conveyed into it on the top, which occaſions ſuch agitation in the water, that it almoſt inſtantly parts with its ſolvent ſpirituous gas, and the ſurface of the water is very ſoon covered with a pellicle from the iron, that refracts ſuch a variety of priſmatic colours, as renders it very diſguſtful to every one who might otherwiſe wiſh to make uſe of it for medicinal purpoſes.

By a trifling alteration in the conſtruction of this bath, and reducing the ſize of it, (for the preſent dimenſions are ſo large, as to make a frequent change of the water in it tedious and troubleſome) the water from the fountains might be readily conveyed into the bottom of it, and all the agitation of the water thereby prevented, and the rapid loſs of the aerial gas in a great meaſure prevented; and a commodious cold bath might be conſtructed at the Tonnelet fountains, of a mineral water in its higheſt ſtate of impregnation with fixed air. But I ſhall at preſent leave the propoſal to the conſideration of the medical world at large, how far ſuch a bath might be uſeful, and in what diſeaſes.—I know of no ſuch bath at preſent conſtructed in Europe, at leaſt of none that with proper attention might be ſo eaſily formed, and at the ſame time ſo abundantly poſſeſſed of ſuch powerful agents, and which the great quantities of water that flow from theſe copious fountains would allow to be ſo frequently changed, and the active powers of the bath to be reſtored many times in the twenty-four hours. Should any perſon be deſirous to have ſo commodious a bath conſtructed, Mr. Briart is ready to give leave to have it made, and to aſſiſt alſo in the expence of the conſtruction.

Before I quit this part of my ſubject at preſent, I ſhall beg leave to give ſome general obſervations on the other ſingular fountain near Spa, the Geronſtere, before I proceed into a more particular enquiry into it, and the future analyſis of the water, as they have been ſent to me by my good friend Mr. Graydon, whoſe aſſiſtance I have before gratefully acknowledged, and who made and repeated many of the preceding experiments after I had left Spa, and in whoſe ſagacity and fidelity I can place the utmoſt confidence.—He writes to me, from Dijon, in this manner: “ The peculiar quality of the “ Geronſtere water ſtill continued to “ give me no ſmall perplexity.—From “ the taſte and ſmell, both which it “ loſes on the application of heat, it “ appears clearly, at firſt view, that it “ contains another gas, and of a different ſpecies from that of the other “ waters; but, as this water gives out “ a gas that will equally precipitate lime out of lime-water as thoſe “ of the other fountains do, as far as “ this circumſtance is to be deemed “ a certain teſt of fixed air being diffuſed in a mineral water, it appears “ to me alſo as certain, that the por-

"tion of hepatic gas muſt be in very "ſmall quantity in this water."

In the courſe of ſome other proceſſes which he made with this water, he met with ſome circumſtances that appeared to him a little extraordinary, and I ſhall beg leave to communicate to the public his own account of theſe difficulties, for their conſideration, in hopes to obtain ſome further light on a ſubject, which may appear, as a phyſical enquiry, not a little intricate, though the ſolution of theſe difficulties may not throw much light upon it in a medical view.

"The air, for ſome time after it had "paſſed, had the ſame hepatic ſmell as "the water before had; but when it "had ſtood ſome hours in the receiving "bottles (in which, by neglect of "the ſervant, a very ſmall quantity of

“ quickſilver had been left in their
“ necks, with a little of the water that
“ came over) the hepatic ſmell went
“ off, ſo far as to be no longer ſenſible,
“ and the gas now differed only from
“ that of the other waters by a very
“ light and barely ſenſible odour,
“ which it is not poſſible to define or
“ even to deſcribe.

“ After this obſervation was made, I
“ was deſirous to get a greater quantity
“ of the gas from this water, to try
“ if any further and different proceſſes
“ could illuſtrate the real nature of it;
“ and, for this purpoſe, wiſhed to procure
“ larger veſſels filled with Geronſtere
“ water; but nothing of that kind
“ could be obtained in Spa, except
“ the double bottle that had contained
“ the quickſilver that had been made
“ uſe of in the other proceſſes: and

" my aſſiſtant having cleaned it, as he " thought, perfectly, filled and adjuſted " it as the other veſſels had been; yet, " in this proceſs, the air, as ſoon as ever " it paſſed, even on its coming through " the quickſilver, had not in any de" gree the ſame ſmell as the fountain " water had.—When the operation " was over, I had the bottle emptied, " and examined it particularly, and " found a conſiderable cruſt of a calx " depoſited by the mercury, and ad" hering to the inſide of the bottle.

Whether this had any or what influence in determining the reſult, he cannot, he ſays, take upon himſelf to determine, or to give any ſatisfactory opinion about the effect; neither dares he preſume to affirm, that it might not have ariſen from ſome defect in the apparatus, though it was in every reſpect the ſame as had been uſed in all the other proceſſes, from the beginning of our enquiries, except in the large ſize of the bottle; and he laments, that he had it not in his power to make any further experiments that ſeaſon, to clear up the difficulty; for the weather continued all the time ſo conſtantly wet, and the rains ſo violent as to ſpoil the fountain water entirely; which deprived him of all hopes of ſucceſs at that time, to extricate himſelf out of this peculiar perplexity. Having before thrown out ſome hints of the improvements that might be made in the quantity, as well as the active powers, of the ſpirituous gas, in theſe ſingular mineral waters, the long continuance of my friend, Mr. Graydon, at Spa, even till the approach of winter, gave him ſtill more convincing proofs of the propriety of them, as well as the impropriety of the preſent conſtructions of the baſons that encloſe all the mineral ſprings; and the laſt unfavourable ſeaſon, towards the concluſion of it, gave him very ſtriking inſtances of the inconveniences ariſing from the preſent ſituation of the Pouhon fountain in particular, as well as ample experience of all the poſſible ill effects of bad weather upon the waters, through the preſent form of its encloſure.

Sunk as it at preſent is, in a hole three or four feet below the ſtreet, nothing can be more obvious, than to ſuppoſe, that whenever any heavy rains fall, ſome of the dirty water will find its way into the baſon; and, in a letter which I received from my learned and ingenious friend, after he had left Spa, I am informed, that he had had an opportunity of ſeeing ſuch an event really take place; for one morning, after a very wet night, the fountain was found covered with a layer, ſome inches deep, of dirty water from the ſtreet; and, what appeared moſt ſingular, was, that it floated over the mineral water, almoſt diſtinct from it, and hardly any part of it was mixed with it, and afforded a ſtriking inſtance of their different ſpecific gravities.

It was conjectured to have entered the baſon by the paſſage through which the ſurplus of the mineral water was carried off; for the water flows into the well in great profuſion: but the poſſibility of ſuch an event taking place, is certainly a great defect in an object of ſuch importance to mankind in general; and this defect may be mentioned with the leſs reluctance, as it is one that may be very eaſily rectified, and at a trifling expence, and there is reaſon to ſuppoſe, that this defect might not only be readily prevented, but that the powers of the water might be greatly improved at the ſame time, as has been before ſuggeſted.

Let us ſuppoſe, that the ſunk court, or area, wherein the Pouhon fountain at preſent ſtands, was filled up to the level of the ſtreet, or a little above it, and at the ſame time the maſonry encloſure of the fountain was raiſed at leaſt to the ſame level; and of courſe the water in the well raiſed as high, or as far as it would riſe; and this might be eaſily tried, though I have not the leaſt doubt of its riſing to the ſame level, when I conſider the nature and height of the hill from whence it is derived.

But, as this fountain is ſo precious, in the opinion of the inhabitants of Spa, the ſmalleſt inſinuations of making any alterations in the ſtructure of its encloſure, would create infinite alarms in the place; and therefore another fountain might be attempted to be made, either above in the ſtreet, or lower down, below the preſent ſituation of the Pouhon; or perhaps with greater propriety on the other ſide of the ſtreet, or ſtill higher up, and oppoſite to it, nearer to the hill from whence all its medicinal ſtores are drawn.

I cannot have the leaſt doubts of plenty of medicinal water, and with equal powers with thoſe of the preſent ſpring, being found there, from the frequent inſtances of finding the ſame kind of water in the different cellars of the inhabitants to the north and north-eaſt of the Pouhon. And moreover, by a proper conſtruction of the new fountain, and its encloſure, the medicinal water contained in it might be ſtill rendered capable of receiving ſuperior qualities, by judicious management; for, by increaſing the depth and the volume of the water, you will increaſe its preſſure, and thereby compreſs the aerial acid into cloſer contact with the ſubſtances held in ſolution, and, by the confinement of its active powers, retain greater abundance of it in the well, as well as of the different ſubſtances that may offer themſelves to its action; ſuch a compreſſion has manifeſtly taken place in the original compoſition of the Tonnelet, in its paſſage towards its ſource, however purer it may be from the various

rious ſubſtances contained in ſome of the other waters in the environs of Spa, that are derived from a different origin than that of the Pouhon.

Such an improvement in the qualities of the mineral waters would render them ſtill more ſalutary, in the relief of a variety of diſeaſes, and of courſe increaſe the number of viſitors that come annually to Spa for the benefit of theſe waters; and ſilence, at the ſame time, the fears of the inhabitants from any innovation being made in their highly-valued Pouhon, and exhilarate their ſpirits in ſeeing ſo much additional company.

The good biſhop might reſt at eaſe, that the profits of the gaming-tables would ſuffer no defalcation, as well as the magiſtrates of the *Communautè de Spa* on the ſame account; and flatter themſelves alſo with the pleaſing hope of greater accumulations of wealth by the ſame *pious* means.

> *Hoc fonte* derivata *præda*
> In patriam populumque fluxit.

While we are upon this part of our ſubject, it may not be improper in a medical view (the chief deſign and intention of theſe obſervations and experiments, rather than any refined chemical analyſis of theſe waters) again to advert to the long-celebrated effects of the Groiſbeeck fountain, adjoining to the Sauviniere, in calculous complaints. Whether the noble baron whoſe title it bears, and whoſe deſcendants have erected a monumental record of his perfect cure from the uſe of theſe waters, really laboured under ſuch complaints cannot now be certainly aſcertained, as the event took place far more than a century ago.

The traditional hiſtory of the baron's complaint aſſures us, that it was occaſioned by ſtones both in his bladder and kidneys; to ſuch a relation it may not be improper to add ſome additional credibility, by giving a ſhort hiſtory of a boy, about five years old, that was ſent to Spa in the ſpring 1787, from Paris, and to whoſe caſe, for my own information, at the time, I paid particular attention, from the middle of July in that year, to near the middle of September, when I left Spa. This boy, from early infancy, had ſhewed ſigns of great pain attending his making water, and after it, and his urine was frequently bloody; he was ſent to Spa for the firſt time in the ſummer 1786, and was ſuppoſed to have received great benefit from theſe waters, and paſſed the winter very comfortably after his viſit to Spa; till, in the month of April 1787, he complained of pain in paſſing his urine, and it was obſerved to ſtop very ſuddenly during its paſſage, and became again bloody: his nights were conſtantly reſtleſs, attended with frequent ſtartings in his ſleep; he gradually loſt fleſh, and in a ſhort time became weak and emaciated. This patient was never ſearched for a ſtone in the bladder; and was again ſent to the Groiſbeeck fountain early in the ſummer 1787. When I firſt ſaw him, in July of that year, he was in a courſe of taking, young as he was, four glaſſes, of 12 ounces each, of the water, mixed with a little milk, in the ſpace of two hours, every morning: he appeared at that time lively and in great ſpirits; told me, with much ſeeming joy, that he had no pain when he made water: though afterwards, about once in a fortnight, he had ſome ſlight returns of pain in paſſing his urine, that continued four and twenty hours, without any other attendant ſymptoms. I left him at Spa, free from thoſe ſlight returns of pain; he had regained all his fleſh, was freſh-coloured, lively, and active, and ran about the walks, near the fountain, with great eaſe to himſelf, and appeared free from every inconvenience from his malady.

The Caroline mineral waters at Carlſbad, on the confines of Bohemia, which were diſcovered towards the cloſe of the fourteenth century, are celebrated for the relief frequently obtained from their uſe in caſes that ariſe from calculous concretions in the kidneys and bladder of urine, and are deſcribed by different writers upon them to be an alkaline water, of a ſuperior degree of heat to thoſe at Bath, in Somerſetſhire, even to be intolerable to the human body till they are ſuffered to cool. They are ſaid to turn green with the ſyrup of violets, and to ſtrike a faintiſh purple with galls, at the fountain; with a ſolution of corroſive ſublimate, to precipitate an orange-coloured powder; and with all the acids, even the weak one of vinegar, are ſaid to make a great ebullition: and on adding ten drops of vitriolic acid to two ounces of theſe waters, the acidity of it was totally deſtroyed; and this mixture, on evaporation, is ſaid to have yielded a tartarum, or kali vitriolatum. They give no ſenſe to the ſmell of any hepatic air in them. Notwithſtanding that ſome of the writers upon the Carlſbad waters, ſtyle the ſalt precipitated from them, when the vitriolic acid is added, a vitriolated tartar, yet others ſay, and with more apparent probability, that the alkaline part, the principal impregnation in theſe waters, is the foſſil alkali, and the precipitate a natron vitriolatum; in the compoſition of them the foſſil alkali is largely combined with the aerial acid; and from ſuch a combination the beneficial effects of the Caroline waters are more fully aſcertained, in the relief of calculous diſorders, than by referring the cure entirely to the aerial impregnation, as ſeveral authors have done: on the ſame principles, the good effects of the Groiſbeeck waters, in ſimilar caſes, have been celebrated for a great length of time.

The ſanguine advocates for the ſucceſs attending the uſe of the *aqua mephitica alkalina* in calculous caſes, will take pleaſure in the hiſtory of the Pariſian boy's relief; as it will hereafter appear, that the mineral waters of Groiſbeeck contain a certain portion of vegetable alkali, as well as a ſmall portion of the foſſil alkali; and, in the opinion of Mr. Margraaff, the vegetable fixed alkali exiſts in nature as diſtinct and completely formed as the foſſil alkali. On dropping a few drops of vitriolic acid on the laſt depoſit from the Groiſbeeck waters, it formed a vitriolated tartar, which it would not have done had the foſſil alkali alone been combined in theſe waters; and this fact may be deemed a further confirmation that the mineral waters of Spa do not contain any vitriolic acid in their natural ſtate.

I ſhall now proceed to the habitudes of the different waters of Spa, when mixed with different ſubſtances, as well as with the different precipitants; and, after the further examination of their different contents obtained by evaporation, cloſe the account with a general table of the reſults of the different experiments made upon the principal waters of the place.

All the acids cauſe an ebullition with the waters of Spa; diſtilled vinegar, as well as vitriolic acid: but the concentrated acids occaſioned a very conſiderable ebullition, and great numbers of bubbles to riſe on the ſurface, and to cover all the ſides of the veſſel, when the waters were freſh taken from the different fountains. But a dilute tincture of turnſole, made from a ſolution of lacmoſs in boiled diſtilled water, ſhewed evident marks of the aerial acid exiſting in them all, by changing it from a violet blue to red, with various ſhades of the colour from ruby red to pink, in proportion to the quantity of water made uſe of, and the quantity of the impregnation in the different waters.

On putting two or three drams of a ſolution of lacmoſs into a tall glaſs that might hold about four ounces, and adding ſome of the Pouhon water taken freſh at the fountain, the colour changed from violet-blue to ruby-red, which increaſed in the brilliancy of the colour till the whole of the water was added; the ſame happened with all the other waters, except in the variations of the ſhades of the ſame colour.

When this mixture was expoſed in a large broad ſaucer to the open air, and left there for an hour or more, on the gradual eſcape of the aerial acid (for no mineral acid would have paſſed from it in the time, ſuppoſe it to have had whatever degree of volatility you could give to it) the colour gradually changed again to the blue colour of the tincture of the lacmoſs; and in a longer time, two hours or more, the contents of the water, together with the colouring matter of the pigment, ſubſided gradually in blue flocculent maſſes to the bottom of the ſaucer; and afterwards, on adding to the mixture ſome drops of vitriolic acid, the blue again diſappeared, and the mixture became of a pale pink; and, with a few more drops of vitriolic acid, by degrees the whole of the depoſit was again diſſolved, except a ſmall quantity of a ſubſtance that appeared like iron in a calceform ſtate.

Milk boiled with all the Spa waters ſuffered no coagulation, but became rather more dilute and thin.

Soap, in ſolution with all theſe waters, formed an equable uniform maſs; but, on dropping a ſingle drop of vitriolic acid in a pint of the ſolution, it immediately curdled into grumous maſſes, and in ſtanding a ſhort time a perfect decompoſition was formed, till at length all the oily parts were detached, and floated on the ſurface in a ſeparate body.

MEDICINAL REFLECTIONS ON THE PRECEDING EXPERIMENTS, AND THE ALKALINE NATURE OF THE SPA WATERS STILL FURTHER CONFIRMED.

The alkaline nature of the waters of Spa manifeſtly appears from theſe experiments; yet ſuch has been the ignorance of their real compoſition, that the generality of authors, under the prejudice of an opinion delivered down from their predeceſſors, without the leaſt appeal to fact or experience, have abſolutely prohibited the uſe of milk in a courſe of Spa waters, whereas nothing agrees better with them than milk, during the whole time of their uſe. Similar too, and on the ſame ill-founded ground, have been their objections to the medicinal uſe of ſoap together with theſe waters, as ſuffering decompoſition through their imaginary vitriolic acid; whereas ſoap, combined with the warm detergent gum-reſins, forms a moſt excellent co-operating medicine with the Spa waters, in all diſorders of the ſtomach and bowels, from either obſtruction or debility: but, in order to remove further every alarming idea of the ſtyptic effects of the Spa waters, I ſhall relate the appearances of them with ſome other precipitants, as they are called, whereby it will appear that the uſe of theſe waters may be extended to various other diſeaſes, in the relief of which the uſe of them has ſuffered an equal prohibition, without daring the hazard of an appeal to trial or experience.

Chryſtallized alkali produces no other effect with them, than depriving them of their pleaſant pungent flavour, by the immediate abſorption of the aerial acid.

And the cauſtic fixed alkali, after twenty-four hours ſeparated only, and that too in a very ſmall quantity, and very ſlowly, a whitiſh calcarious powder.

Salited *terra ponderoſa*, the quickeſt and the moſt certain teſt of vitriolic acid, by eagerly uniting with it whereever it appears, and forming the ſpathum ponderoſum, made no alteration whatever with any of theſe waters, except the very ſingular one at the Geronſtere fountain; in which it will hereafter appear, in the analyſis of them by evaporation, that a variety of ſelenite * was only found in this water, to the very ſmall quantity of leſs than half a grain in a quart.

The blue vegetable juices are in general, though unequally affected, made

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* When you are ſearching for ſelenite in mineral waters, the ordinary appearance of it on chryſtallization, in the form of needles of a larger or of a leſs ſize, is not to be expected always; for, on obtaining the calcarious earth in many of the mineral waters which are the ſubjects of our preſent inquiry, and on dropping the vitriolic acid on ſome of them, to form a true ſelenite, not before exiſting in them, ſuch a one will be obtained, notwithſtanding it will exhibit in chryſtallization a great variety of changes in the form of the chryſtals. Every perſon converſant in ſuch experiments will ſoon be convinced, that theſe varieties really take place in nature, which has been by ſome authors attributed to real varieties exiſting in the ſame abſorbent earth; and Mr. Monnet has taken notice of theſe different appearances.

red by acids; but all the waters at Spa ſtrike green with freſh ſyrup of violets, notwithſtanding the preſence of the aerial acid, with which it has no immediate action: all the alkalies in general ſtrike green with the vegetable juices.

The red watery tincture of Brazil-wood becomes blue with the alkalies, and has the ſame effect with all the waters at Spa.

Alkalies alſo affect the yellow watery tincture of turmeric, by ſubfuſcating it to the brown colours, in proportion to the quantities of them: the ſame will be the effect with paper tinged yellow with this tincture; and all the waters at Spa have the property of communicating to this yellow paper all the ſhades of brown.

The acid of ſugar, and the ſaccharated vegetable alkali, precipitated a ſmall quantity of lime in the Pouhon water.

Alum, with theſe waters, depoſited its earth. — A ſolution of mercury, made without heat, yielded a browniſh yellow precipitate, as did the corroſive ſublimate alſo; but if the ſolution was prepared with heat, the precipitate was of a paler yellow colour.—And a ſolution of ſilver with theſe waters by the alkali, ſaturated with aerial acid, formed a fine white precipitate.

Having thus fully eſtabliſhed the alkaline nature of theſe waters, by ſuch numerous and various teſts, many of which may appear tedious and uſeleſs; and indeed after what had been advanced, in beginning the trial of them with the precipitants, theſe additional experiments may be deemed unneceſſary teſtimonies in ſupport of an opinion that was no longer dubious; yet any attempt to extend the uſe of theſe waters to diſorders for which they have ever been eſteemed improper, if not noxious and deſtructive, may be expoſed to cenſure, and the preſumption be thought highly culpable, if the foundations of the principles, from whence the inferences are deduced, had not previouſly and amply been ſecured.

That the gaſeous mineral waters of Spa are abundantly impregnated with aerial acid, and many of them contain it in greater quantities than can be communicated by any artificial means to water, as will appear from the table before given of the different quantities of aerial acid to be collected from theſe waters, is another fact that has been alſo fully eſtabliſhed.

When I recollect alſo, that, during my reſidence at Spa laſt ſummer, I found that the laborious peaſantry of this country indiſcriminately made uſe of theſe waters, from the fountain that was neareſt to the place of their labour, to ſupport themſelves under the fatigues of their work, expoſed to the heat of the ſun, in the ſame manner as in other countries they make uſe of fermented liquors; and regularly brought their bottles to fill them again at the fountain when they wanted a freſh ſupply; and that they did this conſtantly, without any inconvenience to themſelves, but to their great comfort and ſatisfaction; and a more healthy and active ſet of labouring poor I never ſaw in any country.

Various have been the methods deviſed by ingenious phyſicians of adminiſtering fixed air, for medicinal purpoſes, in a number of internal diſeaſes, as well as externally in cancerous, putrid ulcers, and foul eruptions; and theſe, for very worthy ends, have been communicated to the public, for enlarging the views of other practitioners, and exciting them to make trials of it in ſimilar and other diſorders; but their noble deſigns have not been attended with all the ſucceſs that was to be hoped and expected from them: and I do not recollect a ſingle inſtance, from report, of any invalid being ſent to Spa laſt ſummer, out of the common track of Spa patients, as they were called long before the real nature and uſes of theſe moſt excellent mineral waters were truly and juſtly appreciated.

It has before been laid down, that milk of all kinds mixes equably and uniformly with all the waters of Spa; and there is not a ſingle inſtance that milk ever diſagreed with any perſon, from the bare uſe of the Spa water at the ſame time; and therefore, whenever a milk diet is proper, that will be no objection to the uſe of Spa water with milk.

Whether it ariſes from the generality of conſumptive patients being ſent too late to the hot-wells near Briſtol, thro' the fears of alarming the patients themſelves with the opinion that it was neceſſary to ſend them to thoſe wells; or from what other cauſe, not difficult to deviſe; the annals of the deaths of ſuch patients will ſufficiently prove, that of all the diſorders, for the relief of which theſe ſprings are celebrated, feweſt of the phthiſical caſes certainly receive benefit from them; which by ſome people has been thought an ample teſtimony of their inability to remove diſeaſes, which, perhaps, thro' the delay in their trial, were become abſolutely incurable. They certainly diminiſh febrile heat, and, from their calcarious principle, are abſorbent, and gently ſtyptic: but how this ſubſtance could render them in any degree antiſeptic, is not ſo obvious; but, when the whole language of medicine was made up of ſeptics and antiſeptics, no wonder that Briſtol water was arranged under one of thoſe claſſes; and antiſeptics are certainly moſt favourable to the cure of conſumptions.

Great has been the relief obtained

in the worſt conſumptive caſes from the uſe of fixed air; and ſteel adminiſtered in ſmall doſes, in judicious hands, has frequently been found uſeful in guarding againſt the progreſs of conſumptive diſorders; and this principle will hereafter be found combined in the mineral waters of Spa in ſmall quantities, and under the beſt mode of combination, through the ſolvent powers of the aerial acid. Whether or no a uſeful medicine may not be here offered under this form, diluted in large quantities with milk, and taken from the pureſt of theſe gaſeous waters, may be worthy of the attention of the medical world.

Every ſpecies of the diſeaſes ſo ſtrangely ſtyled ſcorbutic, whether they appear as rheumatiſms, or ſome particular kinds of aſthmas (and are generally ſuppoſed to ariſe from ſome particular acrimony in the fluids, that cloak to all our ignorance, and deform the ſkin with various diſcolorations and filthy eruptions) may poſſibly receive more relief with the Spa waters judiciouſly adminiſtered, both externally and internally, than with any other kind of mineral water; and Bladud hogs, by a previous uſe of the ſulphureous baths and waters of Aix-la-Chapelle, might have been cured of their ſcrophula; and by a ſubſequent uſe of the waters at Spa, have prevented a return of their diſorders, as well as with the waters of Bath.--Every cauſe of debility ariſing from the colica pictonum, or the colica Damnoniorum of England, as well as the enervating effects of other metallic poiſons, eſpecially the improper uſes of mercury, may here find a certain method of relief.

That a fever is a real effort* of all-indulgent nature, to expel ſome morbific matter received by infection, or from the obſtruction of the regular ſecretions of the habit, or various other concurring cauſes, from intemperance and irregular modes of living, is a doctrine of ſuch eſtabliſhed truth, and ſo much confirmed by every mode of rational practice, as not to be readily overſet by the opinion of ſome vain ſpeculative theoriſts; who, being entirely ignorant of the difference of animal heat, as well as other matters of heat, from actual fire, ſuppoſe that a fever may be extinguiſhed with the ſame eaſe by cold air, as all other inflammable matters in a ſtate of combuſtion may with a bucket of cold water. And Hoffman, haſtily enliſted under the banners of this extinguiſhing ſyſtem, is inclined to give it his ſupport; yet, when he is preſſed to explain how the mode of its action can be aſcertained, is forced to acknowledge, that cold water is of ſuch powerful efficacy in exciting febrile motions in the nervous ſyſtem, as may contribute to reſolve obſtructions in the ſmaller veſſels, and diſcuſs the adhering morbid matter.

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* VIS MEDICATRIX NATURÆ.

Although I profeſs myſelf no advocate for the warm regimen in the treatment of either common febrile diſorders or eruptive diſeaſes, and have ever treated my patients in a different manner; yet I am not diſpoſed to believe the uſe of cold baths are proper in every febrile indiſpoſition, or that they can ever be uſed with propriety in obſtructed habits from diſeaſed viſcera; and am well aſſured, that many incipient diſeaſes of the viſcera, as well as chronical diſorders of ſome continuance, ſuch as the jaundice, obſtructions of the biliary ducts from calculous concretions, as well as dropſical complaints from viſceral obſtructions, may receive great relief from the powerful agents contained in the waters of Spa, eſpecially when the patients are duly prepared for the corroborant effects of them by a previous uſe of the warm baths and mineral waters of Aix-la-Chapelle.

And I am clearly of opinion, that theſe ſalutary effects are occaſioned by the action of the gaſeous ſpirit, united with the detergent ſtimulant effects of the pure highly-attenuated ſolution of iron in theſe waters, immediately affecting the ſenſorium; whether it may or may not excite any febrile motions in the ſyſtem, yet they will be ſuch as may be productive of good events in the end, together with the ſedative effects of their alkaline nature in quieting all the tumults and troubleſome effects of flatulence in the firſt paſſages.

And from theſe effects on the ſenſorium, or the origin of the nerves, new vibrations will be excited in every branch of the nervous ſyſtem, for the accompliſhment of ſo deſirable purpoſes; and at the ſame time the waters will tend to reſtore the tone, and invigorate the animal powers to get rid of ſuch obſtructions in the habit, and every other impediment, as far as the progreſs of the diſeaſe will admit, to regain a regular diſcharge of all the animal functions.

To proceed with the remaining precipitants, whoſe effects have not yet been related; but previouſly ſome further particulars may be noticed, with ſome of thoſe already ſubjected to trial for general purpoſes.—The ſingular attachment of the ſalited terra ponderoſa to the vitriolic acid was before obſerved, and wherever that acid exiſts in any mineral water, it will ever attract terra ponderoſa with ſuch eagerneſs, as to deſert every other baſis, and combine itſelf with this earth with ſuch force, that the ſmall united particles remain indiſſoluble for the future.—The attachment of the marine acid to ſilver is as ſingular as that of the vitriolic acid to terra ponderoſa; for, with whatever other baſe it may be united, on adding to the mineral water ſome drops of nitrated ſilver, it immediately unites with the acid, ſhould any exiſt in the water, and forms a precipitate in ſmall particles.

All the waters of Spa, from the volatile nature of their aerial acid, ſuffer great changes in the quickneſs of their taſte, brightneſs of appearance, as well as in the quantities of the ſubſtances held in ſolution in them by means of this acid, through the various changes and ſtates of the atmoſphere; and in the various experiments I daily made upon them for two months together, with the precipitants as well as by evaporation, I hardly ever found exactly the ſame appearances in them, or the ſame reſults, as to the quantity of their contents, for two days together; and the patients conſtantly obſerve, that the waters are daily changing in what they call the goodneſs of them, or their degrees of perfection; and all of them, when expoſed in wide ſhallow veſſels to the open air, ſuffer different changes in different times, in different ſtates of the atmoſphere: as the acid is more or leſs fugacious in the different waters, even theſe degrees of volatility will ſuffer great variations in different temperatures of the air, or as it is more or leſs moiſt; for, in proportion as the aerial acid ſhall eſcape ſooner or later in different ſeaſons, or in different parts of the ſame day, they will alſo ſooner or later loſe their lively and quick taſte, and become in more or leſs time foul and inſipid, and more or leſs of their contents will begin to ſubſide; which can never be deemed the effects of elective attractions to form different combinations, but are only different precipitations, by the bare ſubſidence of their contents deſerted by their ſolvent acid, and in different proportions, and in different times; hence, unleſs the ſame modes of examination are continued for ſome length of time, and on the ſpot, no certain determinations can be formed of their general contents; and hence we meet in authors with ſuch different reſults, collected from a few deſultory unconnected experiments.

A ſolution of mercury made without heat, in the nitrous acid, will throw down a copious yellow precipitate in the Pouhon water, when it is in the higheſt ſtate of perfection; but in a moiſt damp ſtate of the atmoſphere this appearance will not always, and indeed ſeldom take place, and in ſmall quantities; for when neither vitriolic nor marine acid is preſent in the water, the mercury is precipitated by the alkali, and alſo by lime or magneſia diſſolved in aerial acid: when the water is in its beſt ſtate, a ſingle drop of the ſolution will in half a pint of it form a viſible cloud.—If the ſolution is prepared with heat, it becomes more dephlogiſticated, and the precipitate will be of a yellowiſh white, and ſoon becomes white.

When neither a vitriolic or marine acid are preſent in the water with nitrated ſilver, foſſil alkali, aerated lime, or magneſia will precipitate the ſilver in the form of a white powder; but the quantity is not aſcertained, as this alſo is greatly dependant on the ſtate of the atmoſphere: and the ſame happens with acetated lead.

And ſalited lime will be precipitated by fixed alkali in the waters,

ters, after they have ſtood for ſome time.

Though the chemiſts have obſerved that precipitates formed by magneſia, when aerated in waters, are the moſt permanent, and ſubject to leſs variations than others; yet, when the ſolution was prepared without heat, the phlogiſton in the ſolution gave a yellow hue to the precipitate, which was loſt or ſoon diſappeared when it was dephlogiſticated by being prepared with heat; yet magneſia conſtitutes the principal part of the ſolid contents of the Pouhon water, and it is the only fountain at Spa that contains any of this kind of abſorbent earth, as it is the only one that riſes from a different elevation from that from whence all the other mineral waters are originated.

We ſhall now proceed to the remainder of the precipitants, to diſcover the ſecond moſt important part of the medical properties of theſe mineral waters, from the compleat ſolution of iron in them by the aerial acid; and cloſe this part of the account with medicinal reflections on this refined compoſition as a ſedative, invigorating, analeptic tonic.

A ſingle drop of the ſaturated tincture of galls in ſpirit of wine, gives a purpliſh hue to all the waters of Spa, but the ſhade of it will be much the darkeſt in the Pouhon water; and phlogiſticated alkali produces a Pruſſian blue in them all, but more ſlowly in ſome than in others; very quickly, and of a ſtrong colour, in the Pouhon; but in different times, and with different degrees of ſtrength and brightneſs of the colour, in them all.

MEDICINAL REFLECTIONS.

The immediate effects of the Spa waters, on the firſt uſe of them, are ſimilar to thoſe occaſioned by fermented liquors, and in reality ariſe from the ſame cauſe; and if they were, on the firſt trial of them, to be taken in large quantities, they would bring on real intoxication: every perſon, on the firſt uſe of them, will perceive a degree of giddineſs, however cautious he may be in drinking them: but neither common prudence or medical knowledge has yet ſuggeſted one neceſſary caution, in my opinion, which is, that the patients ſhould keep themſelves quiet and compoſed immediately after the firſt uſe of them, and perhaps during the whole courſe of them, and not directly get on horſeback, or make uſe of any ſtrong exertions of either body or mind, as is the uſual practice of the place. Every one muſt have obſerved how the intoxicating powers of ſpirituous liquors are aggravated and increaſed by violent exerciſe, eſpecially on horſeback, as well as by violent agitations of the ſpirits; a ſingle attendance at a country horſe-race will give ample teſtimonies of theſe effects, and fatal may be the conſequences, as well in ſome kinds of bodily diſeaſes, as on the paſſions of the mind, of ſuch dangerous proceedings; yet exerciſe, when duly regulated, is of great importance in promoting the ſalutary effects of theſe waters.

The immediate operations of the aerial gas on the ſenſorium, or the origin of the nerves, will gradually wear away, and new operations take place in the animal ſyſtem, to remove obſtructions and contract and ſtrengthen the nerves.

Cuſtom will render the habit leſs affected by fermented liquors, till it becomes ſo debilitated by their poiſonous effects, that it will require ſtill ſtronger forms of them, and a continual ſupply of them, to maintain its bare exiſtence, till by degrees it loſes all its activity, and ſinks into an unanimated maſs.

The gaſeous principle in the Spa waters, after it has loſt its intoxicating effects, and is aſſiſted alſo by their alkaline impregnation, and its ſedative, reſolving, and detergent effects in the firſt paſſages (ſo totally different from the aceſcent principles of fermented liquors) and united alſo with the ſtrengthening properties of iron intimately combined with it on the general ſyſtem, will tend to appeaſe the debilitated nervous irritations, and excite new ſalutary vibrations in the animal fibres, to remove obſtructions in the viſcera of the abdomen, corroborate the general nervous ſyſtem, and abate its irregular ſpaſms, and thereby renovate and invigorate, in ſome degree, all the powers of animal life.

THE CHEMICAL ANALYSIS BY EVAPORATION.

The mineral water of the Pouhon ſountain has a ferruginous, mildly alkaleſcent,

leſcent, and ſpirituous lively taſte; to which, in the Geronſtere water, though leſs pungent in taſte, muſt be added the ſulphureous taſte and ſmell from hepatic gas. The taſte of the Tonnelet fountain is ſtill more pungent and quick on the palate, but diſcovers its other properties leſs ſenſibly.

After all theſe different mineral waters have been expoſed in a broad ſhallow baſon for ſome time to the open air, a ſhining pellicle, diverſified with a variety of colours, ſpreads in different proportions over the whole of their ſurfaces.

Set any of theſe waters in a ſand-heat, or in a warm balneum mariæ; before they become warm to the hand, they begin to ſparkle and throw up little bubbles, above the ſurface of the waters, in the veſſel that contains them, as if ready to boil, and the pellicle begins to form; in proportion as the degree of heat increaſes, the ſparkling and boiling appearance increaſes alſo in them all, and the ſubſtance of the pellicle is thickened and augmented till it breaks into pieces, and then begins to ſubſide to the bottom of the veſſel, and the water becomes dirty and turbid.

In proportion as they advance nearer to a boiling heat, the various priſmatic colours vaniſh, the pellicle becomes of a dirty reddiſh ochreous colour, and a powder, compoſed of lime or other earthy ſubſtances, and iron, begins to ſubſide to the bottom; the waters then have loſt all their lively taſte, will ſhew no alterations with the precipitants, and are become nearly inſipid.

If you boil any of theſe waters in a glazed earthen or china veſſel, quickly, over a ſmart fire, they will ſoon depoſite a ferruginous powder: collect this powder by means of a filter, dry it haſtily before the fire, and then pour ſome diſtilled vinegar upon it in a proper veſſel.

The gentle acid will diſſolve only ſome of the earthy ſubſtances, and leave the dephlogiſticated iron unaffected.—Precipitate the ſubſtances that are diſſolved in the vinegar by the aſſiſtance of an alkali, and on a proper examination of them, by the rules of chemiſtry, they will be found to be an aerated lime, or ſome abſorbent earth.

In other trials, let the evaporation be continued with leſs degrees of heat from the beginning, till the whole of the aqueous part ſhall be evaporated, and after the appearances already mentioned, on expoſing the different waters in a ſand-heat, or a gentle balneum mariæ, a powder of the colour of ochre has been continually ſeparating, which may be carefully collected from the dry reſiduum by repeated waſhings, properly conducted; when this powder is thus obtained by filtration, on pouring diſtilled vinegar upon it, with which it will gently efferveſce, and in the Pouhon water, the greateſt part, on a chemical examination of it, will be found to be aerated magneſia. In the Geronſtere water, a ſmall part remained untouched, which, on examination, proved to be gypſum, or a variety of ſelenite; but it did not amount to a twelfth part of the whole reſiduum. The reſults of this part of the analyſis will be diſtinctly marked in the general table of the five principal waters.—In all the reſidua of the different waters, this precipitated powder, when properly collected, and treated with diſtilled vinegar, yielded ſmall quantities of different ſubſtances, and all ſtill retained ſome ſmall remains of the dephlogiſticated *debris* of the iron.—I then proceeded to the examination of the different waſhings of the reſidua, which, treated according to the methods laid down in the Introduction, not neceſſary to be repeated (and which are formed on the rules directed by the beſt modern chemiſts, but particularly by Bergman) all exhibited, on chryſtallization, ſmall portions of the mineral alkali, without the mixture of any cubes of common ſalt, that I could ſatisfactorily diſcover, in any of the waters, although I made repeated trials of the ſame methods on the reſidua of every one of theſe waters. And this alkali, when united with the vitriolic acid, formed a true Glauber ſalt in each of them: in ſome of them, ſome chryſtals of a genuine vitriolated vegetable alkali appeared.

Many of the experiments which I made with theſe waters, during my continuance at Spa, were for purpoſes foreign to thoſe of a real analyſis of them; but whenever they were appropriated to that view, the ſtricteſt attention was paid to the exact quantity of water ſubmitted to the examination, as well as to ſeparation, waſhings, and collection of the different reſidua. The quantity of water taken from each fountain, for theſe experiments, was never leſs than five pints, but generally amounted to four quarts;

and the waters were always taken in dry and rather cold days, at which times they are ſuppoſed to be in their higheſt perfection.

As the quantity of water that was taken, to eſtimate the different proportions of aerial acid contained in theſe ſeveral waters, was a quart, or from 32 to 33 ounces, the exact quantity which filled the glaſs veſſel in the apparatus that was then made uſe of; in the following table, the ſolid contents in each water, obtained by evaporation, are proportionally reduced from about two-fifths to one-fourth, in each experiment, according to the quantity of water that was actually ſubmitted to examination, and the reſults eſtimated as if obtained from a quart of each water, Wincheſter meaſure, or 70.50 cubic inches of water.

The whole of the reſiduum obtained from the Geronſtere water, amounted only to about one-third part of the ſolid contents obtained in the Pouhon fountain, and this quantity was ſomething more than what was obtained from any of the other waters, including in the account the three leſs-frequented ſprings, that were not examined, for want of time, with the ſame ſcrupulous attention as the five moſt diſtinguiſhed fountains: and the quantity obtained in the pureſt fountain did not amount to one-eighth of the quantity in the Pouhon.

It is worthy of remark, that all the fountains ſituated on the elevated ground towards the ſouth, and on the oppoſite ſide of the town to the ſource of the Pouhon, contain much leſs in quantity of their ſolid contents than the Pouhon water ; and the higher the fountain was ſituated, on their elevation, the more contents were found in it on evaporation : and the pureſt ſprings were thoſe that were ſituated towards the bottom of this mountain, and on the ſmaller elevations.

The ſame methods of proceeding were taken with all the waters, as were with the Pouhon; and the treatment of the reſidua, to obtain the following reſults, with the exacteſt ſolicitude, was purſued in all.

The Geronſtere water yielded, on evaporation in 70.50 cubic inches –	5 Gr.	50
The Sauviniere – –	3	75
The Groiſbeeck – –	5	25
The Tonnelet, barely –	2	—

Half of this quantity, one-eighth only of the reſiduum in the Tonnelet water, was aerated iron; and of the remaining half, the greateſt part was foſſil alkali, mixed with a ſmall quantity of calcarious earth, of which a very ſmall proportion might be magneſia.

The TABLE.

Fountain.	Quantity of Water.	Solid Contents.	Aerated Lime.	Aerated Magneſia.	Aerated Mineral Alkali.	Aerated Iron.	Selenite.	Aerated Vegetable fixed Alkali.
Pouhon -	33 Ounces.	Gr. 16.25	2.75	9.50	2.25	1.75		
Geronſtere	32.75	5.50	2.50	—	1.75	0.75	— 50	
Sauviniere	32.50	3.75	1.50	—	0.75	0.50	—	1.00
Groiſbeeck	32.25	5.25	1.50	—	1.00	0.75	—	2.00
Tonnelet	32.	2.00	0.25	—	0.75	1.00		

The quantity of water, by meaſure, was always the ſame, as nearly as poſſible, in making the experiments on each of the mineral waters, notwithſtanding their difference in weight. The ſpecific gravity of all theſe waters is ever variable, in different ſtates of the atmoſphere, as taken by the barometer and hygrometer, as well as the thermometer; whether this variation, in all theſe mineral waters, of their ſpecific gravities, is owing altogether to the different quantities of aerial acid they may be impregnated with at the time they were examined; and whether the number of their principles, and the quantities of them, may not always be the ſame exactly in every mineral water (which is not improbable, and I have reaſon, from the number of experiments that I made upon them, to think this to be the real caſe with them); and if the nature of the principles, of which theſe waters are chiefly compoſed, be chemically conſidered, we can have little doubts of the variations in the principles themſelves, as well as of the uncertainty of the quantity of each that may be found in them, in different ſeaſons of the year, and at different times of the ſame ſeaſon, and even at different hours of the day. And, from various other experiments made on theſe waters, and which were not included in the number of the exact and accurate ones from whence the foregoing table was formed, and juſt eſtimations made of the ſeveral contents in the different waters, my experience upon them would fully confirm ſuch an opinion, and leave ſufficient room to ſuppoſe that ſome variety of ſelenite, and eſpecially ſome portion of marine ſalt, may have been really, at different times, found in ſome other of theſe waters, by able chemiſts, than the ſingle one I have mentioned to contain ſelenite; eſpecially when the experiments were not made on the ſpot; for I learned, on viſiting the different fountains near Malmendy and Stavelot, that the mineral waters from a ſpring called Bru, or the grand fountain of Chevron, near Stavelot, have been exported ſome years ago for Pouhon water, and marked as the Pouhon bottles are, to the quantity of a hundred dozen of bottles in a year. The waters of the Bru fountain contain both marine ſalt and ſelenite, and of courſe vitriolic acid in a ſmall quantity. And, on account of the uncertainty of the quantity of each of the ingredients in theſe ſeveral waters at different times, the table was formed on the greateſt quantity of the different ſubſtances I ever obtained from them in the ſame experiment, and when the waters were in their moſt perfect ſtate.

The groſs impoſition on the public, in the exportation of the mineral water of the fountain of Chevron or Bru, for real Pouhon water, makes it neceſſary to give a ſhort account of ſome other mineral waters within ten or fifteen miles of Spa, without detaining the reader with any attempts of an accurate analyſis of them.—The town of Malmendy, ten miles weſterly from Spa, is a pretty village, beautifully ſituated at the bottom of a mountain, on a clear rapid ſtream of water running through it; and is celebrated for manufacturing the beſt leather in Germany, from hides imported from South America; and, though it ſtands in the ancient foreſt called the Ardennes, commands, on the adjoining elevated ſtations, a moſt enchanting proſpect.

The monaſteries of Malmendy and Stavelot, about ſix miles diſtant from the former, but nearer to Spa, conſtitute one chapter, and are ſtyled Imperial; the members of which jointly chooſe an abbot, who, in right of his election, becomes a prince of the Empire, ſovereign biſhop of the principality of Stavelot, and head of both convents, though his general place of reſidence is at Stavelot.—The principal fountain in the neighbourhood of Malmendy is called Le Couve, or Couve de Pouhon; and near to it lies a low, ſlow, ferruginous ſpring, called The Beverſee. To the weſt of the town of Malmendy, about a quarter of a mile from it, and ſo called in the Patois language of the country, is La Sige; this is a very abundant fountain, ſends up large air-bubbles in great profuſion, and is a very favourite one with the people of Malmendy. Within a few yards of La Sige, is a plentiful ſpring of the pureſt water that I met with in this part of Germany, and which is no heavier than diſtilled water. About a mile from, and to the ſouth-eaſt of the town, lies another noted medicated fountain, called Geromont.

There are various other mineral fountains in the principality of Stavelot; but, as they differ from the preceding very little, and are all, I believe, gaſeous ferruginous waters, I ſhall omit taking any particular notice of them, and haſten to the principal fountain

tain of this neighbourhood, within ſix or ſeven miles of Stavelot, and to the weſt of it; but the particular ſituation of it I cannot readily aſcertain, neither could I direct any perſon how to find it, for, through the impracticability of great part of the way with a wheel carriage, I was obliged to make many circumvolutions, and ſuffered great diſtreſs in getting to the place where is ſituated the Grande Fontaine, called Chevron, or Bru, Brue, from the adjoining villages, who all contend for the honour of giving it their own names.

It is impoſſible for any perſon, the leaſt attentive to theſe ſubjects, whatever difficulties he may have in getting to it, not to admire the ſplendor and magnificence of it, when he is arrived thereat. It riſes with rapidity, and overflows the ample baſon that is provided for receiving it, though now going to ruin; in its external appearances it reſembles moſt the fountains of Tonnelet and Niverſet, near Spa. On pouring it from one glaſs to another, it ſparkles as briſkly as the Pouhon water after it is firſt bottled, and covers the glaſs all over, both inſide and out, with brilliant air-bubbles. It leaves a ſtrong acid taſte on the palate; and ſuch is the ſmartneſs of the taſte, that, at firſt taſting it, you are hardly ſenſible of the iron. In the open air, in a few hours, it loſt all its pungency, became flat and turbid, and was of a temperature about 60; and threw up a variegated pellicle, much reſembling that of the Tonnelet. With the ſyrup of violets it ſtruck a deeper crimſon purple than that water; and with the tincture of turnſole formed a beautiful red; and, however ſubtile and volatile the acid appeared at firſt, yet the continuance of it longer in the water indicated ſome more fixed acid to be in it, for it curdled and decompoſed ſoap, yet it made no change when mixed with milk; with the ſaturated tincture of galls, and Pruſſian alkali, it gave evident marks of its iron; and with the ſolution of mercury in the nitrous acid, prepared without heat, it depoſited a white precipitate, that ſoon became of a lemon colour, and gradually of a deeper yellow; with nitrated ſilver it gave ſome ſmall traces of a marine acid, which more eagerly unites with ſilver than the vitriolic acid, and which decompoſed the ſoap, and formed a very ſmall portion of gypſum.—

From this ſuperficial trial of the Chevron water, it will evidently appear in what reſpects it is ſimilar to the Pouhon water, and with what plauſibility it was exported for the genuine water of Spa; and, though an able chemiſt may readily diſcover, by diſtinguiſhing teſts, a difference between theſe two waters, yet theſe marks have, at different times, been ſaid by the beſt chemiſts to be found in the Pouhon water; and ought not to have been the grounds of ſo ſevere a cenſure of them from the body of phyſicians of Liege, near a century ago: unfortunately for their credit, their reprobation of the Chevron fountain, and their attempts to exalt the ſuperior qualities of the Pouhon above it, are founded on a perfect ignorance of the real compoſition of both theſe waters.

Some other motives muſt have actuated them than the welfare and good of mankind, ſo benevolently held forth: Spa belongs to the biſhopric of Liege; and better reaſons ought to have been given, by a body of learned men, for condemning a mineral fountain in the principality of Stavelot, than that the ſolution of iron in the Chevron fountain was a fixed acrid vitriolic ſalt, whereas in the Pouhon it was a mild ſalt of iron: or, that the abundance of ſulphur in the Pouhon (which does not exiſt in it at all) would moderate and reſtrain the activity of the acid; the want of which in the Chevron fountain would render the uſe of the water dangerous in many diſorders, and the corroſive acid, unguarded with ſulphur, would be prejudicial in all.

The analyſis of theſe waters, herein faithfully related, and the principles from thence deduced to be really exiſting in them, may direct and regulate the choice phyſicians ſhall make of them, and point out when it may be neceſſary to interpoſe the uſe of more than one at the ſame time. In the infinite variety of nervous affections, the moſt active and ſpirituous ones may be preferred; when the action of iron, united with abſorbents, is only required, the moſt charged and leſs ſpirituous one may be deemed moſt proper. The volatile aerial acid, in theſe and all other gaſeous waters, gives to their principles their moſt active powers; and in whatever degree hepatic air may alſo be combined in the Geronſtere water, it may give it ſome additional powers in the opinion of a judicious phyſician, and he may uſe his own diſcretion in directing his patients to it.

The ſentiments of different authors, how the aerial acid, ſo abundant in Spa water, is extricated out of the different ſubſtances with which it was combined in the bowels of the earth, are much divided: all the waters at Spa poſſeſs much more of it than they could obtain from the atmoſpherical air; ſuch mineral waters as contain but little more of this acid than all common water does, may be readily furniſhed with additional quantities in paſſing through ſtrata of aerated lime, which are found in various parts of the earth. Three different modes are generally deſcribed by authors, how this aerial acid may be extricated, and in great quantities: 1ſt. By fermentation; but this cannot be admitted to take place in the earth, at leaſt with ſufficient quantities of fermenting bodies to ſupply ſuch infinite demands. 2dly. By ſubterraneous fires: theſe, if admiſſible in the theory of the earth, would expel great quantities of aerial acid from calcarious and magneſian earths; and water would abſorb great quantities of the acid, when more expoſed to receive it, by being divided into many paſſages, through the internal parts of the earth, in proportion to the degrees of its coldneſs, and the degrees of its compreſſure enforced by this ſubtle elaſtic fluid; degrees of compreſſure which art can ſeldom effect. And laſtly, By the action of a more powerful acid: for, although water on the ſurface rarely contains any uncombined mineral acid, yet ſome of them muſt neceſſarily be ſet at liberty in the bowels of the earth, by a variety of cauſes; the deflagration of ſulphur and burning pyrites will detach the vitriolic in great abundance; and the marine acid will be ſet free from magneſia and ſalited lime, through ſubterraneous heat and fires, admitting the reality of ſuch fires in large bodies.

But in the inſtance of the waters of Spa, this laſt, and the ſecond cauſe, cannot readily be ſuppoſed to take place immediately, as they poſſeſs ſo ſmall a quantity of ſaline bodies, and thoſe which they do poſſeſs will, from the very nature of them, require a union of aerial acid, previouſly ſet at liberty by ſubſtances foreign to themſelves and externally of them; for as it appears by the table that they generally contain only mineral alkali, lime, magneſia, and iron, as in the Pouhon and the Tonnelet fountain, and which laſt contains the greateſt ſhare of aerial acid, and which ſubſtances are all aerated: it muſt be clear that theſe waters cannot be aerated by the ſaturations of vitriolic or marine acids, and their ſubſequent decompoſitions and extrications of the acid, or by the decompoſition of ſome middle ſalts to diſtinguiſh ſuch ſalts from pure neutral ſalts, the union of pure alkalies and acids.

There have been many volcanos in the neighbourhood of Spa, and along the courſe of the Rhine, through all theſe parts of Germany, though few veſtiges of them remain at preſent, and are hardly diſcernible, they are ſo defaced by the lapſe of ages.

The admiſſion of ſubterranean fires

in ſmaller quantities than to produce earthquakes, or any other violent commotions, is more readily granted; provided only that the ſuppoſed cauſes are ſo attemperated in their effects as to remain the ſame efficient agents in the production of them.

Neither is it neceſſary that ſuch efficient cauſes ſhould always be very near to the places from whence the waters iſſue; for the cavities and perforations through the ſuperficial ſtrata of the earth are ſo numerous and diverſified, in ſuch a variety of directions, that the ſupplies of ſuch an elaſtic fluid may come from very remote diſtances; and the circumſtance of the water having depoſited all its heat, will ſerve to confirm the opinion, that the air has paſſed through a very long courſe from its firſt extrication.

If martial vitriol only is diſſolved in water, and you ſhould ſuppoſe this water to paſs through ſtrata compoſed of either mild alkaline ſalts, lime, or magneſia, it may, by decompoſing theſe ſubſtances, ſet at liberty great quantities of aerial acid, which may be conducted to very remote diſtances, and be there combined with water; which water ſhall exhibit, beſides its aerial acid, only ſlight impregnations of thoſe original ſubſtances, from whoſe decompoſition ſuch abundance of this permanent elaſtic gas was originally extricated.

Bergman ſays he has ſometimes found a ſmall portion of gypſum in Spa water. In Sweden he could be ſupplied with only the Pouhon water, ſuppoſing that he always had the genuine Pouhon water when he did find the gypſum, and that he never got any of the ſuppoſititious Pouhon, or the mineral water of the Chevron fountain, near Stavelot; and which water entirely decompoſes ſoap, though in other reſpects it reſembles the Pouhon water; in the livelineſs and briſkneſs in its taſte, as well as in its alkaline nature, and the quantity of its iron. Yet he ſeems to be at ſome loſs to explain how this could happen; for he ſays alſo, that moſt commonly gypſum did not appear in the water of Spa; unleſs, as he really ſays, the water in which it appeared was taken from ſome other fountain; and he doubts, moreover, whether the number of principles be always the ſame in the ſame water. Had Bergman made his experiments at Spa, he could not have doubted of their variation: and he moreover ſtill ſays, that he is confirmed in the opinion by experience, as well as the nature of the thing itſelf, that the proportion of the ingredients in the water muſt frequently vary.

He expreſſes his difficulty of knowing how this could happen in this manner, if we ſuppoſe a diſengaged mineral alkali (or an alkali only united with aerial acid) to be preſent, as ſuch an alkali attracts the vitriolic acid more powerfully than the lime does; Whence then comes the ſelenite? And he reſolves the cauſe of the gypſum, if really preſent in the Pouhon, being ſeldom found in it, and, when found, to be only in very ſmall quantities, by the inactivity of the aerated mineral alkali, by ſhewing that the combination of mineral alkali with aerial acid is never ſpontaneouſly decompoſed; and that ſubſtances which are ſo thinly diſperſed through the water, muſt act very ſlowly upon each other: and explains alſo how the activity of ſubſtances is repreſſed by being united with aerial acid, in the inſtance of vitriolated magneſia diſſolved in water:—Drop a little of this ſolution into lime-water, and the magneſia inſtantly drops to the bottom of the veſſel, having yielded its acid to the lime: but if pieces of chalk or calcarious ſpar are put into the ſolution, no decompoſition can be produced even by boiling: and vitriolated magneſia does really exiſt in Seydſchutz water, together with aerated lime.

It is humbly hoped, that the learned and judicious phyſician, who has never viſited theſe fountains at Spa; from this conciſe but faithful examination of their waters on the ſpot, will be able to eſtimate the medicinal qualities of each of them, and of the excellent water of the Pouhon in chief, as a mild but active and powerful tonic; and be enabled to interpoſe the uſe of any other of theſe juſtly-celebrated ſprings, or direct his patients to any one of them in particular, as his knowledge of their conſtitutions, and the ſeveral diſorders they may labour under, may ſuggeſt to his wiſdom and penetration, for the general benefit of mankind, and the credit and honour of his profeſſion.

THE

ANALYSIS of the MINERAL WATERS

OF

AIX-LA-CHAPPELLE,

AND THE ENVIRONS.

IF, under the denomination of ſulphureous water, we ſhould include only ſuch waters as contain real mineral ſulphur, as it is found native in a great number of places, or prepared by art from pyrites, this claſs of mineral waters would be reduced to the ſmalleſt of all the claſſes: and the beſt chemiſts have determined, by real experiment, that the ſulphur which is united with iron and argillaceous earths in the pyrites, is an imperfect one; and many of theſe experiments were made on pyrites that contained neither arſenic or copper.

From hot ſulphurated waters, an hepatic vapour is eaſily collected, whoſe preſence is diſcovered by its peculiar ſmell; and when this is preſent, united with aerial acid diſengaged, it will be decompoſed by pure air on its quitting the water: the hepatic aura is very tenacious of its vaporous form; yet, when large and dry ſurfaces are expoſed to the atmoſphere, the pure air in common air will attract the phlogiſton, which, as long as it maintained its vaporous form, was the bond of union of the ſulphur with the matter of heat; when this union is diſſolved by pure air, the ſulphur will appear in its proper form, and from hence are formed all thoſe maſſes of real mineral ſulphur, found in the arches of the fountains, and of the aqueducts to carry off the waſte water from the fountains at Aix-la-Chappelle; for the hepatic vapour is really decompoſed whenever any ſubſtance is united with it, that will attract and ſeparate its phlogiſton.

Real ſulphur and water can never be united together, without the intervention of another ſubſtance; and this union of an intermediate ſubſtance with ſulphur forms, in the language of chemiſtry, the hepar or liver of ſulphur. This intermediate ſubſtance is either pure alkali, or ſome alkaline abſorbent earth, moſt frequently the calcarious earth. The defect of real ſulphur in a ſtate of union with many mineral waters, that are generally ſtyled ſulphureous ones, is not occaſioned by thoſe waters containing in them no ſubſtances that are proper to form ſuch a union by the intervention of them, as in the hepars; for many of them contain foſſil alkali and abſorbent earths, held in ſolution: yet nothing is more uncommon to be found in theſe waters than any true hepars, according to the opinion of good chemiſts; for if you add to theſe waters a ſmall quantity of any genuine hepar, a few drops of a concentrated mineral acid will precipitate real ſulphur, not readily diſcoverable in them before.

To ſuppoſe that the ſolution of theſe alkaline ſubſtances, in ſo large bodies of water, prevents their acting with ſufficient powers to be combined with the ſulphur, and form an hepar, will not be deemed a clear explanation of this imaginary difficulty; nor will the aſſertion that the degree of heat in ſuch waters is not adequate to produce the union, be deemed more ſatisfactory, ſince there are many cold mineral waters that have the ſame hepatic ſmell.

A phyſician from Leyden, ſome few years ago, who had reſided ſeveral weeks at Aix-la-Chappelle, for the purpoſes of making experiments on the waters, related to ſome of the faculty of the city, that a ſolution of arſenic in the marine acid would exhibit a precipitate of genuine ſulphur, that was diſſolved in the water at Aix, and kept ſuſpended in it by the means of fixed air.

A good chemiſt would deem this experiment to be highly problematical; for the precipitate might be formed by elective attraction from the arſenic, on the marine acid uniting with the abſorbent earth, and form a marine ſalt with an earthy baſe; or with foſſil alkali, and form a true marine ſalt.

And though the precipitate is related to be found, after ſome days, covered over with a ſubſtance of a yellow colour, this would not prove it to be real ſulphur, any more than the yellow precipitate in the Spa waters, procured with the ſolution of mercury in the nitrous acid, prepared without heat, would lead you to ſuſpect that thoſe waters contained alſo ſulphur; which was never ſuppoſed but by the college of phyſicians at Liege, a century ago; and in the record which I ſaw of this fact, it is not mentioned which of the three kinds of arſenic the waters had been treated with, and two of them are prepared with real mineral ſulphur.

Many chemical authors have imagined a certain affinity and mutual predilection between arſenic and ſulphur, and from its property of mineralizing metallic bodies, ſuppoſed it to be a real ſulphur; yet, though the regulus of arſenic, as well as orpiment and realgal, are capable of inflammation, pure white arſenic is not; and it muſt be clear from theſe appearances, that its ſulphureous properties are admiſſible only in ſome certain circumſtances. Zinc and other metallic bodies are inflammable, which can by no means from thence be called ſulphurs, except merely to indicate thereby the great quantities of phlogiſton they may contain, and properly combined to have this effect; and the ſame may be ſaid of inflammable air, and from thence many ſuppoſe it to be the ſame as hepatic air. Mr. Scheele of Sweden firſt elucidated the diſtinct properties of the acid of arſenic, and eſtabliſhed the true nature of it by the moſt deciſive experiments.

Mr. Macquer, in his report to the *Academie Royale des Sciences* at Paris, concerning the mineral waters of Montmorency, obſerves, that theſe waters precipitated ſolutions of metallic ſubſtances in a mineral acid, in the ſame manner as real hepars would have done; but that with the acid alone no precipitate whatever was found: and he obſerved alſo, that as ſoon as the precipitate was formed by the metallic ſolutions, the ſmell of the hepatic air was loſt; this he attributes to the air attaching itſelf to the metallic ſubſtances, and thereby loſing its volatility.

From the reſults of ſeveral of his experiments on theſe waters, he was at firſt induced to believe that the ſulphureous waters of Montmorency contained real ſulphur in them; but, on a further critical examination of them afterwards, by other methods of trial, he never could obtain any real ſulphur from the waters themſelves in their natural ſtate; yet at the ſame time he cautions againſt arranging theſe particular waters under the ſame claſs with thoſe which contain only the vapour of ſulphur, which is more properly called hepatic air, ariſing from the hepars of ſulphur, and whoſe nature is ſo fully explained by Bergman.

The reaſon why Mr. Macquer was unwilling to arrange thoſe ſulphureous waters, that contain only hepatic air, in the ſame claſs with thoſe of Montmorency, was this, that, had all theſe kinds of waters been arranged under the ſame denomination, it would have been neceſſary that none of them ſhould have contained any ſalt, combined with a vitriolic acid, which would be required to eſtabliſh the fact of the real decompoſition of the ſulphur.

So much has been already ſaid in the Introduction on this copious ſubject, that I am in danger of repeating the ſame obſervations; but if I ſhould be ſo happy as to place them in a different point of view, my readers, who are not much converſant with a ſubject in many reſpects not very familiar to any, and which is alſo of ſo ſubtle and intricate a nature, may pardon the offence.

The hot hepatiſated waters may be alſo *aerated*, as will manifeſtly appear in theſe mineral waters of Aix-la-Chapelle, and may be readily diſtinguiſhed from plain, hot, aerated waters, ſuch as are the waters of Plombieres, united with hepatic air, as well by the general tenor of their characters, as by their difagreeable ſmell.—All the waters in the city of Aix-la-Chappelle have the ſmell of the hepars. Every ſtranger that comes to viſit the city of Aken and its baths, muſt, on his firſt approach to any of the ſprings, be ſenſibly ſtruck with the ſmell which ariſes from them all; but, on entering into any of the rooms where the waters are kept, eſpecially after they have been emptied, cleaned, and filled again with the waters freſh from their ſources, the ſmell of them muſt be highly ungrateful and diſguſting to him. They will all blacken ſilver and other white metallic bodies, as will the vapours ariſing from a variety of other ſubſtances, in fermentation or putrefaction; and a genuine ſulphur is depoſited in great maſſes on the ſtone roofs that cover the wells, as well as on the inſide of the arched aqueducts that convey the waſte water from the greater ſources; and will be found actually depoſited in the mud and other ſubſtances at the bottoms of the aqueducts.

And yet the moſt accurate analyſis had not hitherto been able to diſcover in the water the moſt minute particle either of the hepar or of ſulphur: but Mr. Bergman thinks he has unfolded the myſtery in this manner, by relating that every hepar ſulphuris, upon adding to it ſome drops of a more powerful acid, generates a ſpecies of air, which he, as well as Dr. Watſon, calls hepatic air, if every permanent elaſtic fluid, not condenſed by cold, may be called an air.

And this powerful acid he found in a highly concentrated nitrous acid, *Hoc nempe acidum*, ſays Bergman, *phlogiſton arripiendo, ſulphur, ejus ope materiæ caloris adunatum, deturbat, quamvis conſuetas explorandi methodos omnino eludat: acidum nitri concentratum, juſtâ inſtillatum doſi, mox fœtorem tollit, quod decompoſitionem certò indicat, ſulphur tamen ſubtiliſſimè diviſum lentè ſubſidet.*

And the ſubſidence of it was indeed ſo very ſlow, that I never had the happineſs to ſee it, in either the Geronſtere water at Spa, or in the ſulphureous waters at Aix-la-Chappelle, although I had furniſhed myſelf, before I left England, with the beſt concentrated nitrous acid, from the excellent practical elaboratory of Mr. Willis, chemiſt, at Hermitage wharf, Wapping. Any water, he ſays, impregnated with this kind of air, reſembles the hot hepatiſated waters: hepatic air contains true ſulphur, *ſed ita ſubtiliſatum, ita expanſum, ut viſum fugiat,*

fugiat, and puts on the appearance of common air.—That it contains real ſulphur, however modified and ſubtilized, I am firmly perſuaded, although I did not happily obtain a ſight of it depoſited in ſubſtance from either of theſe waters; yet, till more efficacious methods can be deviſed of finding it in an expeditious manner, the concentrated acid produces no other effects on the water than common air, by the pure air contained in it, will have on the vapour when it has eſcaped from the water, and the aerial acid has alſo eſcaped, and real ſulphur is formed by ſublimation on the arched roofs of the aqueducts; neither will the diſcovery be of ſo great importance as he boaſts of, in the analyſis of mineral waters that may be juſtly called ſulphureous, either hot or cold, if the detection of the ſulphur in them is ſo readily accompliſhed by the common operations of nature.

When artificial hepatiſated waters are made, by being impregnated with this hepatic air, and as fully combined with aerial acid as many of theſe waters are; how far an immediate depoſition of the ſulphur thus given to the water, may be obtained by a proper quantity of a concentrated nitrous acid, I cannot pretend to ſay, as I have not made a compleat ſet of experiments with that view, but, after the many repeated and unſucceſsful trials of nitrous acid, with the Geronſtere water at Spa, I ſhould have been almoſt as much ſurprized to have ſeen it really ſubſide in the waters of Aix-la-Chappelle, as a raſcal of an alchemiſt would have been on diſcovering a true tranſmutation of the metal, when he had not previouſly and ſecretly conveyed ſome real gold into the crucible.

It is well known, by every perſon verſed in chemical experiments, that the hepars of ſulphur are liable to decompoſition, but with different degrees of celerity, in proportion as they are diffuſed in different quantities of water, and expoſed to different degrees of heat: and the hepars made with lime decompoſe ſooner than any of the others. And it is reaſonable to ſuppoſe, that in the original formation of ſulphur, either native in the bowels of the earth, or eſpecially in the artificial manufactories of it, that the ſulphur ſhall ſeldom be formed pure and uncombined with other ſubſtances, and that it frequently attaches to itſelf ſome fuliginous matter of an aſphaltous nature, and which will adhere ſtrictly to it, remaining firmly united with the intervening ſubſtance after the ſulphur ſhall be decompoſed; and, if this combination be expoſed to moderate degrees of heat, till nothing ſhall remain in it but the aſphaltous ſubſtance and the fixed alkali, yet this combined ſubſtance will retain the ſmell of the hepar, and affect the organ of ſmell in the ſame manner as genuine ſulphur, or the hepatic air, and the vapour that ariſes while it is over the fire will turn all white metallic bodies of a blackiſh colour.

After having advanced thus much relating to the hepars of ſulphur, if I might be at liberty to form any conjectures how theſe appearances relating to ſulphureous mineral waters take place in the phyſical world, I ſhould venture to advance the opinion, that in all ſuch combinations of a mineral or abſorbent alkali with aerial acid in the ſulphureous water, and united with phlogiſton in different proportions, the hepars, if there are any really in them, would be immediately decompoſed on their iſſuing into the open air; the phlogiſton be gradually diſſipated, and attracted by the pure air, always exiſting in common air; and the acid, ſtill retaining the hepatic ſmell, alone remain in the water, having united with, and in ſome degree or other aerated the alkaline ſubſtances held by it in ſolution in the water.

In ſuch hepatic waters the decompoſition will be accelerated by the diſſipation of the phlogiſton; by the ſame means the hepatic ſmell may ariſe from the fermentation and putrefaction of vegetable and animal bodies; and the vapour from both will diſcolour metallic bodies.

This hepatic air, though not volatile in any very great degree, is permanently elaſtic, and cannot be concentrated in a leſs volume of the water; and this phlogiſtic vapour, when it is detached from the acid, enjoys to the taſte and ſmell all the properties of them both when in a combined ſtate, though, when the hepatic air is entirely detached, no real ſulphur does or can exiſt in the water.

No regular proceſſes were undertaken at Aix-la-Chapelle, or the environs, to eſtimate the exact and comparative proportions of fixed air in the different ſprings, as well on account of the great length of time it would have required to have done it with preciſion in ſuch a number of them, as the little neceſſity that appeared for inſtituting them, for in the trials that were made none of them appeared to contain more than 24 ounce meaſures of fixed air, in 70.50 cubic inches of the water, the ſame as was collected from the Geronſtere water at Spa.—Bergman has eſtimated the quantity of hepatic air in the waters of Aix-la-Chapelle, which he had never viſited, in the proportion of 13.068 grains to a pint, Wincheſter, or 35.25 cubic inches, and puts the real ſulphur in them to be in the ſame quantity of water at 1 grain, 7424.

All the mineral waters of this claſs are as capable of being chemically analyſed by evaporation, in order to collect their principles or ſolid contents, as any other mineral water, and the ſame precipitants may be employed as were made uſe of with the Spa waters.

The ſenſe of ſmell ſeems alone capable of aſcertaining the quantity of hepatic gas united with the fixed air, in theſe, or indeed in any of theſe gaſeous ſulphureous waters. And the modes of aſcertaining the quantity of real ſulphur, contained in any of them, muſt be equally equivocal and fallacious.

All theſe waters, on expoſure for a time to the open air, loſe intirely their peculiar ſmell; and that in a quicker manner, or more ſlowly, as they are expoſed to greater or leſs degrees of heat; and if, on expoſing theſe kinds of waters to the open air, or to diſtillation, they really contain no other kinds of ſubſtances, they then become in no degree different from common water. It may be neceſſary to remark, that the mineral waters of Aix ſuffer very little or no change in them, from the different ſtates of the atmoſphere, as was manifeſtly the caſe with all the different fountains at Spa; whether this may ariſe from the cloſe coverings of all the ſources of theſe waters I cannot determine; and I had not time to obſerve, whether, in the open fountains of the adjoining village, ſuch alterations in different ſeaſons really took place; but this probably is the caſe in all gaſeous ſprings.

Although the fact, that certain ſubſtances, when mixed together and expoſed to the open air, ſhould a ſufficient quantity of water from rain, or any accidental cauſe, be united with them, will frequently grow hot, even to burſting out into a real flame, muſt have been obſerved by many curious inquirers into natural appearances; yet the illuſtration of this ſuppoſed origin of ſubterraneous fires and volcanos, by actual experiment, is due to the induſtry and ſagacity of Lemery. By forming equal quantities of powdered ſulphur and iron filings, with a ſufficient quantity of water, into a paſte, and putting this compoſition in an iron pot, inverted, and buried a foot or more under the ſurface of the earth; in a few hours the earth grew warm, and heaved; hot ſulphureous vapours iſſued through the fiſſures in the ground, till a motion was perceived in the earth, and actual fire burſt forth, with the effects of a real earthquake, producing a volcano on a ſmall ſcale, by the reciprocal action of iron, ſulphur, and water.

Many other compoſitions of the ſame materials, mixed with various other ſubſtances, will produce ſimilar effects; and the explanation of the chemical cauſes of theſe appearances will tend to illuſtrate this otherwiſe obſcure fact, if true, though other phænomena may lead to the confirmation of it, that the matter of heat is the real union of vital air with a determined quantity of phlogiſton. This was the opinion of Mr. Scheele, and from him adopted by Bergman, till he afterwards retracted it; as were many of the moſt valuable diſcoveries of Scheele; and he is at all times ready to acknowledge his extraordinary acumen and ſagacity in matters of chemiſtry. Modern chemiſtry makes two diſtinct ſubſtances of the matter of heat, and phlogiſton; in the room of the latter, as thinking it unneceſſary, Mr. Lavoiſier has ſubſtituted pure air to anſwer all its purpoſes.

Iron, ſoaked for a length of time in water, forms a martial calx or æthiops on its ſurface; with bare humidity, a ruſt. Sulphur in water lies inert. Mix the iron and ſulphur together, no action will take place, till the addition of water ſhall communicate a moiſture to them: granting then, as the fact is certain, though the mode of action may be unknown, that the water expels the phlogiſton from the iron, the ſulphur will then attract the iron deſpoiled of part of its phlogiſton, and thereby promote a farther diſcharge of it: by this mutual action on each other, the phlogiſton will be expoſed on every particle of the metallic calx to action, and attract the vital part, or pure air, from the common air, till this united body grows warmer in proportion to the quantity of pure air imbibed, till it ſets the ſulphur into combuſtion; and by theſe means all the foregoing appearances and effects take place, in proportion to the quantity of the accumulated materials.

From the lavas thrown up by different volcanos, it is evident that martial and other vitriols, aluminous and gypſeous ſubſtances, as well as a variety of other combinations with calcarious, argillaceous, and ſiliceous earths, are generated in them in immenſe quantities; and theſe ſaline bodies, mixing with the other bodies, and agitated by the violence of the combuſtion, will ſeparate and pour forth in great abundance all the different gaſeous auras, to be propagated and diſperſed through the infinite cavernous and perforated cavities, in every poſſible direction, under the ſuperficial coverings of the globe, for ages to come; and, though no volcanic mountains at preſent appear in theſe countries, yet the evidences of their former exiſtence, in a variety of places, are inconteſtible. And hepatic, as well as fixed and other airs, may be intimately combined with the various waters exiſting in the bowels of the earth, till, on iſſuing into the open air, the phlogiſton may be again united with pure air and acids, again forming the concrete maſs of real and genuine ſulphur; not to inſiſt in this place, on what has been ſo often mentioned before, eſpecially in the Introduction, the various other modes from whence different waters may be impregnated with hepatic air.

Here it may be right to notice an

obſervation on the Geronſtere water, that was omitted in its proper place: It has been obſerved in the Introduction, that ſome waters, in which were contained portions of rotten wood, had been found to be impregnated with the ſmell and taſte of other hepatic waters; now, immediately on the higher ground, above the Geronſtere fountain, was found a large extenſive moraſſy ſwamp, ſurrounded with many old pollard trees; and this *fange*, as they call it in the country, was filled with thick muddy water, containing many decayed vegetables, branches of the neighbouring trees, with various other ſubſtances, ſo as to render it ſafe to ſtand upon it in many parts.

The imperial city of Aken, or Aix-la-Chappelle, ſtands in an open plain, ſurrounded with various riſing hills, at moderate diſtances, one of which, called Louſberg, is to the north of the city, and very near to it; on aſcending it, a pleaſing proſpect of the whole city and its territory is to be obtained.

The city is amply furniſhed with freſh water; and, from the numerous devaſtations it has ſuſtained by fires, in different centuries, great attention has been paid to prevent ſuch diſaſters for the future: the firſt reſource is by a ſmall rivulet, conveyed from the hills on the ſouth-weſt ſide, in an open aqueduct, into and through the city, in which it turns various mills, and ſerves for the uſes of breweries, fullers, dyers, tanners, &c. and may be occaſionally ſtopped in its courſe, and conveyed into reſervoirs for extinguiſhing fires, and other uſeful purpoſes.

The ſecond ſupply is derived from ſources ſouthward of the former; this is a much lighter and ſimpler water than the preceding one, and more uſeful in all the purpoſes of common life. —But the beſt and pureſt water in the city is derived from a ſource within the territory of it, to the north-weſt, within the diſtance of about two Engliſh miles; it is called the *Seſſen*, and is one of the pureſt waters I ever examined.

Every ſtranger who ſhall viſit theſe fountains, muſt be wonderfully ſtruck with the immenſe quantities of water daily iſſuing from them, and which have been celebrated through ſo many centuries for their thermal medicinal qualities, as well as their diſagreeable odour.

There are many ſources in this city

of theſe mineral waters, not neceſſary to be diſtinctly enumerated, which are all naturally hot, but not of equal degrees of temperature, even in their original ſources; but the degrees of heat are ſtill more variable in the different baths that are derived from ſome of the ſources, from their ſituations, ſizes, and greater or leſs remote ſituations from the principal original ſource; for many of them come from more than one of theſe primary ſources.

The principal ſource, called Cæſar's, or the Emperor's Bath, from Charlemagne, riſes almoſt in the center of the city, in a declining ſituation, eaſt of the town-houſe, and to the north of the great church, where the relics of Charles the Great are preſerved with great veneration.

From the depth and volume of the

water in this principal ſource, as well as its being cloſely covered with a large grit-ſtone from Normandy, and confined by iron-bars with different locks, the keys of which are kept by the principal magiſtrates of the city, it is impoſſible to form any opinion of the manner in which it riſes up into the ſource; yet, from the compariſon of it with the leſs important ſprings, and the nature of its compoſition, it is reaſonable to ſuppoſe that it ſprings up with a conſiderable quantity of aerial gas, accompanied with a ſparkling appearance and bubbling noiſe.

And when we conſider the number of aqueducts to carry off the ſuperabundance of water—and the number of baths which it ſupplies in different houſes, ſome of which are very large and commodious—and the conſumption

tion of waſte water that runs from all theſe baths through the ſtreets, to ſerve the purpoſes of waſhing linen, and other uſes; it appears impoſſible to aſcertain the quantity of water which the different ſources daily ſupply.

In all the bathing houſes there are accommodations of all kinds and ſorts. 1ſt. Common hot baths, that will hold from one ſingle perſon to ten or twenty, in whatever poſture or ſituation they may require. 2d. Vapour baths, in which the whole body alſo, except the head, or any part of it, may be included, and expoſed to the warm vapours of theſe waters, in their natural ſtate, or eaſily raiſed to any degree of heat that may be thought proper. 3d. Pumps, which are ſo conſtructed, that one or more columns of water, of greater or leſs dimenſions alſo, may ſall on the whole body, or any particular part, and from different heights, or in different directions.

4thly. Moſt of the bathing houſes are provided with dreſſing-rooms, with or without beds, and all of them with beds to lie in, to ſweat or to cool after the uſe of any of the baths, as well as dry hot rooms; and they have all apartments for lodgings, properly provided, and many of them are neatly and elegantly furniſhed.

At the fountain, as it is called, which is ſituated with a pump in an open ſpacious cloyſter, and ſo named in particular to diſtinguiſh it from the other ſources made uſe of for bathing, or to which the ſtrangers reſort to drink the waters; at this fountain, the pump of which is at ſome diſtance from the covered ſource from whence it is raiſed, the taſte and ſmell of the mineral waters are leſs diſagreeable and offenſive, than when taken from the more cloſe and confined ſprings.

It is difficult to deſcribe and aſcertain the peculiar taſte of theſe waters; and this want of preciſion in their taſte will lead the ſtrangers, on their firſt arrival, to compare it to a variety of offenſive taſtes, as their own feelings ſhall direct them to whatever gives them particular diſguſt; but habit and cuſtom in the uſe of them wonderfully leſſens this diſagreeable taſte, and, in a ſhort time, it will become ſo far familiar, as not to appear at all nauſeous to them.

The temperature of the heat in the ſeveral ſources of theſe waters, is ſomewhat different in all of them; but I found a very trifling variation in the ſtandard heat of each fountain, through the different ſtates of the atmoſphere.

At the Emperor's bath, in the water raiſed by the conducting pipes from near the bottom of the well, Fahrenheit's thermometer ſtood at - -	136
In the water iſſuing from the waſte pipe at the top, at only	128
From the well at the new bath	133
In a ſource or well common to two baths, and St. Quirinus's	120
In that of St. Cornelius - -	115½
In the Roſe bath - - - -	115
In the baſon at the fountain, where the water is received for the drinkers - - -	112
But in the covered ſource, from whence the water is raiſed and conveyed	

conveyed thro' wooden pipes
to the fountain, to above - - 134

WITH THE PRECIPITANTS.

1. With the ſaturated tincture of galls, as well as with the fine powder of them, in none of theſe hot medicinal waters, either in their natural ſtate, or when they had been kept in a veſſel perfectly cloſed up twenty-four hours, and became quite cold, any other change whatever appeared in them, than that they became muddy and tinged with the proper colour of the galls.

2. With the phlogiſticated alkali, no other change whatever happened, with the water in both the ſame ſtates, than in rendering them, after ſtanding

together ſome time, tinged, and ſlightly too, with the paleſt ſhade of green; not the leaſt trace of a Pruſſian blue.

On adding a ſingle drop of vitriolated iron, to a pint of the water taken from the waſte pipe at the Emperor's bath, both the ſaturated tincture, and the phlogiſticated alkali, gave evident teſtimonies of the preſence of this ſmall quantity of iron contained in a ſingle drop of the ſolution.

3. With the tincture of turnſole, or a ſolution of lacmoſs, each of the waters, when taken freſh from the ſource, turned the blue colour of it to a bright purple, but leſs of the roſe red than the waters at Spa; but on letting the water ſtand till the aerial acid had eſcaped, this colour faded away, and the mixture became of a blue colour, the ſame as the pigment.

4. With ſyrup of violets, the leaſt certain teſt of alkali, none of theſe waters immediately made a change in the colour of the ſyrup; but with half an ounce of it, added to two ounces of the thermal waters hot from their ſources, they became in two minutes of a ſea-green colour, which gradually aſſumed a brighter hue; with the water when cold, the change was ſlower, and the colour muddy and leſs bright.

The concentrated acids all occaſioned conſiderable ebullitions, but no depoſit was formed from the waters with any one of them.

5. Salited terra ponderoſa diſcovered not the leaſt trace of a vitriolic acid being contained in theſe waters, by forming with it any appearance of a ſpathum ponderoſum.

6. Nitrated ſilver gave evident marks

of a marine acid in theſe waters, by its immediate ſeizure of the ſilver, which ſubſided gradually in the waters like a mucilage.

7. Nitrated mercury, made without heat, diſcovered alſo the marine acid; and when prepared with heat, and was thereby dephlogiſticated, the precipitate with the aerated mineral alkali was at firſt yellow, yet ſoon became whitiſh.

8. Acetated lead formed a white powder with them.

9. Alum depoſited its earth.

10. The acid of ſugar precipitated part of the lime.

11. With ſoap they formed a tolerably equable ſolution, but not uniformly ſo as with the waters of Spa; and, a ſingle drop of vitriolic acid being added to a pint of the ſolution, it imme-

diately curdled, and became in time perfectly decompoſed.

12. With milk, on boiling, they formed no coagulation.

MEDICINAL REFLECTIONS.

Hot hepatiſated gaſeous mineral waters, in which are combined, in a large portion, the aerated mineral alkali, united with nearly equal quantities of an aerated lime and marine ſalt, without any ſtyptic or aſtringent ingredients in them, will hold out to a medical mind, well ſtored with judicious obſervations, and minute inveſtigations of the riſe, progreſs, and terminations of a variety of human diſeaſes, under ſo happy a compoſition, a uſeful, gentle, purgative and diuretic medicine; and abſorbent at the ſame time, in the relief of acidities, and other conſequences of originally weak or impaired powers of digeſtion; invigorated with the active gaſeous acid, and ſtimulating effects of the hepatic air, in the aſſiſtance of their attenuating, diſſolving, and detergent effects: but if he extends his views to their various uſes as tepid or hot baths, the effects of them in the humid or hot dry vapours, in relaxing contractions of the limbs, indurations of the ligaments, and other ill conſequences of diſeaſes or external injuries from wounds, bruiſes, and various other cauſes, and in the relief of irregular nervous ſpaſms and convulſions, or their ſtimulating and corroborant effects by the different modes of the external application of them, as well as their cleanſing and healing effects in various diſeaſes and deformities of the ſkin, and cutaneous membranes; he will think them highly deſerving of his attention, when judiciouſly managed, and not forget any of the ill conſequences that muſt ever attend the improper uſe of ſo powerful remedies in very weak habits, as well as in hot feveriſh conſtitutions, ſubject to inflammations of the lungs and hæmoptoes, as well as to eryſipelaſſes and inflammations of the cutaneous and cellular membranes.

In cold ſcorbutic and chronic rheumatiſms they muſt claim his attention; and, ſituated as they are, he may find reaſon to deem them a moſt excellent preparative for the uſe of the ſtrengthening, corroborant neighbouring waters of Spa, in a variety of caſes, where the union of both theſe waters in ſucceſſion may be attended with the moſt laſting and beneficial effects.

BY EVAPORATION.

Though the mineral waters of Aix-la-Chappelle have ſo ſingular a diſagreeable taſte, which is alſo ſtrongly alkaleſcent, yet the moſt nauſeous part of the taſte and the ſmell entirely vaniſhes in a ſhort time, on expoſing them to the open air; the ſmell may be again reſtored, for a ſhort continuance, by heating them afreſh; but after it has been once reſtored to them by heat, it can never be afterwards revived; and if, on their firſt expoſure, they have remained a long time in the open air, the revivification of the ſmell will never be obtained.

Set a glaſs of theſe waters, taken freſh from the Emperor's bath, in a ſand-heat or a warm balneum mariæ, and though the water appears, at firſt taking, clear, bright, and pellucid, it will very ſoon part with its ſtrong diſagreeable ſmell, and a pellicle then begins to appear on the ſurface, formed from the lime, and increaſes in proportion as the aërial acid is more or leſs diſſipated by the different degrees of heat in the ſand-heat or the water bath: this pellicle does not appear variegated with a variety of colours, as in the ferruginous waters of Spa, but aſſumes a duſky whitiſh hue; and a ſimilar appearance, of the ſame colour, ſhews itſelf in the body of the water, as if ſome earthy ſubſtance was precipitating, that was held in ſolution by the acid before it was diſperſed from the water.

On expoſing theſe waters to a ſufficient degree of heat to continue the evaporation, in the ſame gentle manner as was practiſed before, in the analyſis of the Spa waters, and continued to dryneſs, the whole of the reſiduum that may be collected, after the evaporation of 70.50 cubic inches of theſe different mineral waters, will amount to ſome quantity, from 46 to 58 grains; and in moſt of the waters the reſiduum was gritty, with various appearances like little ſcales, which had a ſaline taſte, and were all of a whitiſh colour from moſt of the noted ſprings; for I cannot ſay that the trial by evaporation was extended to them all.

When theſe reſidua were collected, waſhed, and weighed, as in the proceſſes with the waters at Spa, they were afterwards treated with alcohol, cold diſtilled

led water, and boiling water, and afterwards filtrated; the remaining parts of the reſidua, not ſoluble in either alcohol or water of different degrees of temperatures, were then treated with vinegar; the acetous ſolution, after the treatment of it, and the aerated lime collected, was afterwards evaporated to dryneſs, and then further treated with a diluted vitriolic acid, but no ſelenite appeared in it, nor vitriolated magneſia; and the part not ſoluble in the vinegar was ſo extremely ſmall, that it could be hardly eſtimated: the different waſhings were next treated in a manner agreeable to the rules of chemiſtry. It then appeared, from the reſults of all the different treatments of the ſeveral parts of the reſiduum obtained from 70.50 cubic inches of the water taken at the

Emperor's bath, and raiſed from the bottom of the ſource, that 58.50 grains of the reſiduum were collected, and then properly treated, there appeared,

Of aerated Lime,	Aerated Mineral Alkali,	Salited Mineral Alkali,
14.50 Gr.	30.75.	13.25.

On the examination of the other mineral ſources by evaporation, the ſame modes of treatment were inſtituted, though not with equal accuracy, as in the water from the Emperor's bath, and no eſſential difference was found in any of them, with regard to their ſolid contents, except in ſome ſmall variations in the quantities of the ſame ſubſtances.

The varieties in the different degrees of heat in the ſeveral ſources, have been already noticed; and no attempts were made to aſcertain the different proportions of the fixed air contained in the ſeveral waters, as, on the few trials that were made with ſome of them, the quantity obtained, in none exceeded 24 ounce meaſures in 70.50 cubic inches of water, which was nearly the quantity collected from the Geronſtere water at Spa.

It can hardly be worthy of notice, that the leaſt quantity of reſiduum, though not in any conſiderable variation, was collected from the ſource of the fountain where the waters are taken internally.

THE WATERS OF BORDSCHEIT, or BORSET.

BORDSCHEIT is now a conſiderable village, within leſs than a meaſured mile of Aken, with a church and a convent of nuns; and the ſeigneury of the place is veſted in the lady abbeſs of the convent, who generally appoints one of the burgomaſters of Aken her adminiſtrator. It is a manufacturing town of cloth-workers, who are induced, by the great abundance of naturally hot lixivial water, ſo neceſſary in their manufactory, to make it the place of their reſidence.

There are two ſets of thermal waters at Borſet, called the upper and lower hot-ſprings; the upper baths ſpring through the fiſſures of a gritty rock, at the bottom of a high hill, whoſe ſtreams united ſoon form a current ſufficient to turn an overſhot mill.

In the middle of the principal ſtreet is a circular baſon, eight or ten feet in diameter, and near five deep: this baſon exhibits a very extraordinary appearance; the water is as clear as chryſtal, and perfectly reſembles a large boiling cauldron, throwing up large bubbles, which burſt on the ſurface with a bubbling hiſſing noiſe. From this ſource, and many others, a great number of the bathing-houſes, which are fitted up with the ſame conveniences as in the adjoining city, but on a cheaper and leſs expenſive plan, for the accommodation of people of inferior rank, are amply ſupplied with their mineral water. Theſe ſources contain no hepatic air.

The lower order of ſprings are more diſtant from Aken, and are all ſulphureous; theſe fountains are very numerous, and ſome of them within 300 yards of the hot ſprings in the village, and near to the ſtream of waſte water from the other baths, with which uniting, they form a large fiſh-pond, and a dam for a mill.

It is no part of my plan to enter into any minute diſcuſſion of the difference between the waters of Borſet and thoſe of the neighbouring city; though, from the few trials which I made with them with the precipitants, and one or two evaporations of the different ſorts of fountains at Borſet, I have no reaſon to apprehend any material difference between them, with regard either to the nature or quantities of their ſeveral contents. Perhaps theſe waters may be leſs ſtimulant than the waters at Aken, and upon that account may be more ſuitable in all habits that are diſpoſed to inflammatory diſeaſes: from the want of hepatic air in the upper ſprings, the baths are leſs offenſive, and of courſe their uſe muſt be much more pleaſant and agreeable to thoſe who frequent them.

I ſhall therefore only make ſome curſory remarks on theſe waters, with a ſhort account of a chalybeate ſpring, called the Spa, within the walls of the city of Aix, and cloſe this article with ſome further medicinal reflections on the whole.

The Caroline waters in Bohemia, except in the very ſmall quantity of iron which they are ſaid to contain, reſemble in moſt other reſpects the upper ſprings at Borſet: the Caroline and Borſet waters are both very abundant in their fixed air, they are both devoid of hepatic air, they are both alkaline, and the degrees of heat in the Borſet waters muſt at leaſt be equal to thoſe of the Caroline.—The water in the open baſon in the ſtreet raiſed Fahrenheit's thermometer to 140, four degrees higher than the water immediately raiſed from the bottom of the grand ſource at the Emperor's bath; and in a little open fountain belonging to the upper ſet, but ſituated lower in the town, it was raiſed to the amazing height of 156 in ten minutes.

It is ſaid, that if a fowl or a ſwine be dipped in the Caroline water three or four times, all the feathers of the fowl, as well as the briſtles of the hog, will come off; and I ſaw ſeveral of the common people dreſſing calves feet with the water from the fountain in the lower town; ſeveral kettles were ſtanding round it with bacon and greens, as well as eggs dreſſing in them; and in the time that I walked down to view the lower ſprings, an egg that I had left in the fountain was boiled hard. If a dependance can be put on the relations of the evaporation of the Caroline waters, a quart of them depoſited a dram of an alkaline powder, half of which was an alkaline ſalt; another account ſays it was the foſſil alkali, and ſeventeen grains of the remainder was an abſorbent earth: compare this hiſtory with the reſults of the trials on the reſiduum of the water from the Emperor's bath.—Becher ſays that iron was contained in the waters of Aix-la-Chappelle, which is not true; and I believe that he found, by his account of them, no iron in the waters at Carlſbad.

May it not have great future uſes, that proper trials ſhould be made of the efficacy of the waters at Borſet in particular, as well as at Aix-la-Chappelle, in a variety of calculous diſorders?

Through a miſtaken notion of the real compoſition of the waters of Borſet, on enquiry I learned, that the uſe of them internally is very ſeldom directed; for, more through zeal of emolument than true knowledge, a general opinion is propagated throughout Aken, that the mineral waters of Borſet are impregnated with alum; whereas ſuch people as have drank them for ſome continued time relate, that they are really more opening and purgative than the waters of Aix. It has been before obſerved, that alum very rarely makes a part of any mineral water: and I ſatisfied myſelf clearly, by real experiment on the ſpot, that the mineral waters of Borſet did not contain the ſmalleſt portion of alum, properly ſo called.

However ſurpriſing it may be thought by moſt people, that two ſets of mineral waters, ſuch as are the upper and the lower ſprings at Borſet, which are ſo nearly ſituated together, and the ſprings of each ſet ſo numerous, ſhould all ſo materially differ from thoſe of the other ſet, that all of them in the upper ſet ſhould not contain hepatic air, whereas all the ſprings in the lower one are ſulphureous: now, if the ſuppoſed means by which the ſingle fountain of Geronſtere, near Spa, became impregnated with hepatic air, may be deemed to be rationally accounted for, (the hiſtory of which was by accident omitted, while we were treating upon that water, and barely ſuggeſted in the account of the ſulphureous waters of Aken) a more ample teſtimony of the probability of ſuch a cauſe really taking place will be here more abundantly evident, as the ſprings of ſulphureous water are ſo many in number, and no other or more probable cauſe of ſuch extenſive influence can be found out.

Not far above the lower ſet of ſprings, and between them and the caſtle of Frankenberg, ſituated on the top of the eminence, from the bottom of which all theſe fountains iſſue, lies a very extenſive moraſs, that was very ſoft and tender in the middle of Auguſt laſt ſummer, ſeemed full of water, and which I had no reaſon to doubt penetrated deep into the earth, and which was covered over with ſuch vegetables as generally grow in ſuch kinds of ſoil.

I have before noticed a ferrugineous ſpring, which was ſituated within the walls of the city of Aix-la-Chappelle, and which, on viſiting it, I found to be a gaſeous one: it is called the Spa, lying near that additional part of the town called the Comberſtadt, and which, on a ſlight examination, I had reaſon to ſuſpect contained a ſmall portion of vitriolic acid.—And here, in a medical view, it may not be improper to make ſome obſervations on vitriolic waters in general.

All mineral waters, hot as well as cold, that poſſeſs any great efficacious powers, muſt contain greater portions of aerial acid than common water does: all other ingredients, of whatever kind they may be, are heavy and inert, without the aid of this elaſtic vapour; and indeed their greateſt excellence is entirely owing to the quantity with which they are impregnated of this active and ſubtle fluid: for all cold mineral waters, on expoſure to the open air, will ſoon part with their aerial acid, hot ones much ſooner. Though the aerial acid gives to all waters their greateſt efficacy, yet the uſe of mineral waters is not ſolely confined to this acid; Seltzer and Pyrmont waters are both highly gaſeous, yet they both poſſeſs groſſer ſaline bodies, and to theſe the aerial acid gives their active and penetrating powers; as to the chryſtallized mineral alkali in the Seltzer, as well as it aerates the lime and magneſia; and in the Pyrmont, to the vitriolated lime, magneſia, and ſalited mineral alkali, as well as it aerates the lime, magneſia, and iron. Cold mineral waters may be divided alſo into ſuch as contain iron in them, and others that are totally deſtitute of iron: the ferrugineous are more frequent than any other kind of waters, and many of theſe contain the iron, either totally or in part only diſſolved by the vitriolic acid; and the knowledge of this is of great importance to the phyſician in directing the uſe of them. There was a time when vitriolic acid was deemed by them all the only ſolvent of iron; whereas it is well known at preſent, that ſuch vitriolic waters are very rare; and happy it is that this is the caſe, for though, when ſlightly impregnated, theſe waters may have their uſe, yet they, for the moſt part, are improper, and frequently injurious to the patient. As there is plenty of chalybeate ſprings, the beſt ought to be ſelected: whenever the iron is totally diſſolved by aerial acid, the beſt of the kind will be formed; and ſuch waters will ever be moſt efficacious, when they are directed with judgment. There is alſo a third claſs of ferrugineous waters, in which the iron is diſſolved moſtly by aerial acid, and by a ſmall portion of vitriolic acid. Such waters, though not equal to thoſe in which the aerial acid is the only ſolvent of the iron, yet may be taken with advantage, when better cannot be readily obtained.

Hot aerated or hepatiſated waters may be eaſily imitated; and, if the aerated hot water only is required, aerate diſtilled water in the common manner, and ſuſpend the veſſel containing it (which may be ſo formed as to reſemble Papin's digeſter) in a balneum mariæ; which, when gradually heated to any degree of heat that may be required, will readily communicate the neceſſary degree of heat to the incloſed veſſel.

Hepatic air may be communicated to diſtilled water, by putting ſome powdered hepar ſulphuris, prepared by melting ſulphur and pot-aſhes in a crucible, in the room of the chalk that was employed to aerate the preceding water; and proceed, as in the other proceſs, as well to hepatiſate as afterwards to heat the water to whatever degree may be required: and in the ſame manner large quantities of water may be aerated or hepatiſated, to form baths of them, by means of a long flexible tube, communicating with the proper ſubſtances prepared and mixed together, and the other end introduced into the bottom of the bathing tub; and may be ſo conducted as not to affect reſpiration, while the patient is ſitting in it.

Real mineral ſulphur is more readily precipitated from the artificial waters, by the proper mineral acids, than when found in mineral waters in the form of an hepatic air, and communicated through ſuch a variety of natural proceſſes.

THE

MINERAL WATERS, and BOUE BATHS,

OF

ST. AMAND,

IN FRENCH FLANDERS.

THE real exiſtence of bituminous ſubſtances in any mineral water, is rejected by ſome of the beſt modern chemiſts, for reaſons, incompatible with their own ideas of the modes of union between real ſulphur and water: they are immiſcible in water; ſo are all genuine ſulphurs: ſhould an alkaline ſubſtance intervene, they are capable of being united; the ſame is applicable to bitumens: petroleums, agitated with diſtilled water, ſeparate again upon ſtanding; ſo will any genuine ſulphureous body.

Yet they ſay that the water, with which the bituminous ſubſtances are agitated, ſtill retains, after the moſt careful filtration, a ſtrong bituminous ſmell; all ſulphureous bodies, agitated with diſtilled water, will leave an hepatic air iſſuing from the water, till evaporation takes place: If an hepatic air remains for a time, why ſhould we wonder if a more diſtinguiſhable aura of bitumens ſhould alſo remain in it, however temporary it may be?

And why is not ſuch an aura, which is equally permanent and elaſtic with hepatic air, to be ſtyled a bituminous air, ſince the latter may contain as little of the original bitumen as the former will be found, in general experiments, naturally to contain of real ſulphur?

The bituminous aura has an equal title to be called real aſphaltum, as the latter has to be deemed genuine ſulphur.

Whatever Lucas has advanced on the real union of fetid oils from putrefaction, or bituminous ſubſtances with water, is either ſo inconſiſtent with the true principles of chemiſtry, or ſo debaſed with the malignity of perſonal abuſe, and enervated with the debilitating poiſon of ſelf-ſufficiency, that it is hardly worthy the notice of a diſintereſted inquirer into the ſimple operations of nature.

About the middle of the way between Tournay and Valenciennes, the town of St. Amand is ſituated, on the banks of the Eſcaut or Schelde, about thirty miles from its ſource in Picardy. On leaving the town of St. Amand,

and paſſing by a gentle deſcent, near two Engliſh miles, you arrive at the mineral fountains diſtinguiſhed by the name of St. Amand; they lie about half a mile diſtant from the Eſcaut, and near forty feet below the bed of the river.

All the country about St. Amand abounds with pit-coal, the chief article of conſumption for fuel, and called by the French Charbon de la Terre. On approaching the fountains, you become ſoon ſenſible of the ſame kind of ſmell as you perceive when near to any ſulphureous waters, yet ſomething different in its ſmell ariſes from theſe; and, when very near to them, it becomes ſtill more diſagreeable than the vapour from the generality of this claſs of mineral waters: if any diſtinction is neceſſary to be made in the ſmell of ſuch hepatic airs, I ſhould be induced to ſtyle this particular one an aſphaltic air.

Genuine ſulphur preſents to us one of the moſt ſimple combinations, conſiſting only of two principles, an acid, namely, ſaturated with phlogiſton; whereas, in the opinion of Bergman, the compoſition of petroleum, under that name comprehending all this claſs of phlogiſticated bodies, is more intricate; imagining that a ſmall portion of water, by the means of the acid, is combined with the inflammable principle: all the ſpecies of amber more evidently diſcover their origin to be derived from the vegetable kingdom; for beſides their proper acid and oil, vinegar is evidently diſcovered in them by diſtillation, while the earthy reſiduum may be conſidered as their matrix.

Within a ſpacious building (adorned without by a handſome inſcription, laying claim to the high antiquity of theſe mineral waters, from the time when the Roman legions harraſſed theſe countries, and made uſe of theſe baths for the relief of their diſabled ſoldiers) and in a large room belonging to the edifice, are placed two fountains, incloſed in two diſtinct areas, ſix or ſeven feet below the floor of the room, one called Bouillon, or Bouillant, The Boiling Fountain; to which diſtinction it has no real title; and the name may have been given to it in compliment to a great French commander with that title, for there has been a military hoſpital eſtabliſhed at theſe fountains for more than a century paſt. The other is called The Fountain of Arras, or L'Eveque d'Arras.

Both theſe fountains reſemble in appearance ſome of thoſe at Aix-la-Chappelle, as well in their brilliancy as in throwing up great quantities of their air, although in an inferior degree; as they are inferior alſo to them in the degrees of heat, for in neither of them was the mercury in Fahrenheit's thermometer raiſed above 75, when in the open air it ſtood rather below 50 degrees. Neither did the water with the precipitants diſcover the leaſt traces of iron being diſſolved in them; although it might be ſo ſubtilely diffuſed as not to act with precipitants; for on a ſubſequent analyſis of the boue, iron was diſcovered in it; and I had not time to try, by evaporating different portions of the water, whether then any changes would be wrought in their appearance.

But the moſt ſingular circumſtance attending the waters of St. Amand is, that in a ſlight large building of wood, erected within a ſmall diſtance of the fountains, and in a form reſembling a green-houſe, the whole front to the ſouth being made of glaſs frames irregularly put together, are contained more than a hundred boue baths; part of which are reſerved for the uſe of the company who may viſit theſe ſprings; another part are appropriated to the French ſoldiers, who are ſent to the military hoſpital here, erected at the expence of the King of France, where theſe unfortunate men, who are either wounded at land or ſea, or otherwiſe diſabled from the hardſhips attending a military life, are regularly ſent, and maintained at the public expence during a courſe of theſe waters and baths.

The remaining baths are kept diſtinct for the uſe of the poor diſtreſſed ſick and lame inhabitants of the adjacent country.

Each bath is of an oblong ſhape, and formed and ſeparated from each other by wooden frames, rather more than five feet long, and about three wide; the depth of the boue in the baths could not readily be aſcertained, as will more evidently appear hereafter: as to the conſiſtence of it, they are all more or leſs liquid, yet the boue in all of them is in ſo firm a ſtate, that no invalid can be forced down into them, without firſt digging out part of the boue, which is all of a dark blackiſh colour.

I before ſaid, that the depth of the boue could not readily be aſcertained in the baths: for in order, if poſſible, to obtain a knowledge of the real depths of the fountains, I procured out of the adjoining woods a ſtaff or pole 28 feet long; on putting it ſeparately into each of the fountains, I perceived in both of them, about 6 or 7 feet below the ſurface, the boue, firſt in a very looſe texture; the conſiſtence grew firmer, as I puſhed the ſtaff lower down, but it was frequently interrupted by ſome ſolid bodies, perhaps large ſtones; in time I readily preſſed the whole length of it to the level of the water in both fountains; but I cannot pretend to ſay how much deeper the boue might be, as I could not any way procure a rod of ſufficient length to make more effectual trials.

The boue or mud in the baths retains the ſame ſulphureous or aſphaltic ſmell, but by its expoſure in ſo large and open a building, it is deprived of great part of the heat which it muſt have had in the fountain; yet, when the thermometer was put more than a foot deep into the boue, it raiſed it to near 63 degrees, at a time that in the open air it did not riſe higher than 47, it being early in the morning, rather cold, on the 15th of September, and before the ſun was up.

The method that at preſent prevails in the uſe of theſe baths, is to bury the lower part of the body of the diſeaſed perſon in them, and up to the arm-pits if the diſeaſe is ſeated in the upper part of the ſpine, or to immerſe a part only, or any of the limbs affected; and the patient is to remain in it, either in an erect poſture, or reſting on the ſurface of the boue, with blankets or a ſheet interpoſed, for ſome hours, as the caſe may require, and afterwards to be carried to a hot bath, to be cleanſed from this black mud that ſticks faſt to the parts that have been immerſed in it.

When converſing with the worthy Dr. Harrington, on a viſit I lately made to Bath, concerning theſe ſubjects, he informed me that his uncle, who practiſed phyſic at Bath, many years before my ingenious friend came there, was uſed to relate to him, that when he firſt came to Bath, it was cuſtomary to make uſe of the boue, collected at the bottom of their baths, as an external application, and to keep it, if poſſible, in the ſame degree of heat as when it was firſt taken from the bath: and my learned friend Dr. Marcard, of Hanover, who has lately publiſhed a very ſenſible treatiſe on the Pyrmont waters, tells me, that it ſtill continues to be cuſtomary,

mary, at Pyrmont, to make uſe of the boue collected in the baths there, as an external application in a variety of caſes.

Beſides the baths formed in the boue, commodious baths are here alſo conſtructed to receive the mineral waters raiſed up from the fountains below; and the degree of heat is now, and might be readily, by art, ſtill further and more conſiderably increaſed: and although there are ſome pumps erected for the douche, and ſome attempts made to conſtruct proper vapour baths, yet the accommodations of the place might ſtill be rendered much more convenient and efficacious, and the ſalutary effects of both the water and boue baths might be ſtill greatly improved.

One moſt excellent cuſtom, had it

been faithfully executed, has formerly prevailed at theſe baths, and ſtill prevails, in ſome degree, though the practice gradually diminiſhes (yet it is better kept up, I believe, in the military hoſpital) which is, to have a regular regiſter kept of the caſes ſent to St. Amand; in which was entered an account of the ſymptoms and ſituation of the patients when they firſt arrived; and an account alſo regiſtered in the book, from the phyſician who recommended them there; to which was afterwards annexed an account of the benefits (not always perhaps ſtrictly true) that each patient had received during his courſe of theſe waters and baths; and this laſt account of the cure was formerly ſigned by the patients themſelves: but if every degree of credit is to be paid to ſome of the accounts that are entered on the books, and from thence given to the public by a variety of authors, who have wrote upon the mineral waters of St. Amand, ſuch extraordinary cures have been effected by them, as would exceed the belief of the moſt credulous men.

All the writers, who, from motives of intereſt, or with more honourable views, have given to the public their obſervations on the effects of that claſs of mineral waters which are called ſulphureous, are very copious in their praiſes of them in venereal diſorders; whether theſe pretences, ſuppoſing them to be real, are founded on their efficacy in the relief of ſuch diſorders as are the conſequences of an improper uſe of mercury, or on any ſpecific effects they may have on the peculiar virus of that diſorder, cannot admit of a doubt by ſenſible men; yet the claims of ſtill more extraordinary virtues, in the relief of that diſeaſe, have been advanced and maintained with the greateſt zeal by many authors, in behalf of the waters and baths of St. Amand; inſomuch that ſome of them have even expreſſed a doubt, whether they did not contain ſomething mercurial in their compoſition.

It has been before obſerved, that all the country about St. Amand abounds with mines of foſſil coal, and that it makes the chief article of their fuel; every inquiſitive perſon, who has lived for any length of time in a country abounding with coal mines, and has viſited them, and inquired into the nature of their component parts, will have reaſon to be of opinion, that a great part of their compoſition was originally in a vegetable ſtate; and might be led to ſuppoſe, that in ſome violent commotions of the earth, in very remote periods of the exiſtence of this terraqueous globe, deep beds of peat, together with the trees and other vegetable productions growing on its ſurface, might be buried in ſome places very deep below it, and there combined with bituminous ſubſtances that were in a liquid form; from this ſtate of them, in the combination of theſe bodies together many ages paſt, the ſuperior parts of the ſtrata of foſſil coal would contain moſt of this lighter part of the compoſition, which in all coal mines is called the kennel-coal; and the quantity of the bituminous parts growing leſs and leſs downwards, till towards the bottom of the ſtrata, ſtony and other heavier bodies are combined with the other bodies, this part of the mine being the leaſt valuable as an article of fuel.

I once found, in the middle part of a ſtratum of coal 14 yards thick, a conſiderable branch of an oak-tree, diveſted of its bark, but in all other reſpects a piece of unconverted wood, and to all appearance as firm and undecayed as it was when it was originally depoſited and lodged in the center of ſo large a maſs.

The two fountains of mineral waters at St. Amand, though ſo near to each other in ſituation, appear different in the quantity of their component parts: they are, however, ſimilar in the degrees of heat, neither of them raiſing the thermometer above 75 degrees; yet the Bouillon is leſs abundant in its aerial gas, as well as in its peculiar air; and on evaporation, the ſame quantity of its water yielded a few grains leſs of ſolid contents than did the water of L'Eveque d'Arras.

The ſaturated tincture of galls, and the phlogiſticated alkali, as has been before obſerved, gave no evident teſtimony of any iron being contained in theſe waters; though there was great reaſon, from other appearances on the ſpot, to have expected ſome marks of it with theſe precipitants. It is not uncommon, when the ſolution is highly attenuated, and the quantity very ſmall, that the iron will not appear with the precipitants till the water is half evaporated; and ſometimes the evaporation muſt be ſtill further increaſed, before the teſts will give evident ſigns of iron in the water.

Half an ounce of freſh ſyrup of violets, mixed with two ounces of the water, from both the fountains, ſtruck a faint green colour : yet the ſalited terra ponderoſa precipitated a ſmall quantity of a ſpathum ponderoſum, which was an evident proof of ſome portion of vitriolic acid being combined with theſe waters.

The nitrated mercury, prepared without heat, precipitated a greyiſh powder, which ſoon grew of a darker colour; and the precipitate with the acetated lead was ſtill of a darker colour. Nitrated ſilver ſhewed ſigns of a ſmall quantity of a marine acid alſo in theſe waters.

With the ſolution of ſoap, the mixture was not equable or uniform, but ſhewed few ſigns of a real decompoſition taking place.

The concentrated acids occaſioned a ſmall ebullition, and the acid of ſugar threw down a ſmall portion of lime.

The tincture of turnſole became of a faint red, but the concentrated nitrous acid precipitated no ſulphur.

Before I proceed to the evaporation of theſe waters, and the chemical analyſis of the reſidua, it may be neceſſary to inform my readers, that the difficulties attending the removal of my apparatus for that purpoſe, in the proper manner I could have wiſhed, from Spa and Aix-la-Chapelle to this place, and the utter impoſſibility of procuring any conveniences there, or at the neighbouring town of St. Amand, prevented my performing it on the ſpot, in ſuch manner as I hoped, and may be expected: and therefore, on compleating the evaporation of theſe waters, in the ſame mode as in the other waters, I put the reſidua in glaſs bottles cloſely ſtopped up; and took with me ſeveral pounds of the boue, procured at leaſt a foot below the ſurface, packed up in a proper veſſel and cloſely covered up; having contented myſelf with ſuch trials as I could conveniently make at the baths, and deferring a more minute examination of them till I was in poſſeſſion of more correct means of doing it.

On putting ſmall quantities of the boue on different pieces of iron, heated in different degrees, it diſcharged at firſt only watery vapours, but the vapour ſoon became of a ſulphureous or aſphaltic ſmell, emitted a blueiſh and ſometimes a reddiſh flame, till it was nearly all conſumed, and a few aſhes only from the earths remained on the pieces of iron.

As I had taken ſeveral parcels of the boue with me, at the firſt convenient place that I could procure a commodious apparatus, which was Paris, I expoſed one parcel of it to diſtillation in a reverberatory furnace; after the watery parts were exhaled, I put a receiver to the retort, and having properly luted the veſſels, I directed the fire to be raiſed to a ſtrong degree, and continued it for ſome time, when I procured half an ounce or more of a liquid of a deep red colour, which was filtrated through paper barely moiſtened with pure water; and this liquid evidently appeared to the taſte and ſmell to contain a volatile alkali; it efferveſced ſtrongly with a moderate vitriolic acid, ſenſibly ſo with diſtilled vinegar, and but very little with the marine acid.

On evaporating 70.50 cubic inches of theſe waters at St. Amand's baths, over a very gentle fire, the pellicle did not begin to ſhew itſelf ſo ſoon as in thoſe of Aix-la-Chappelle, and part of it, when it appeared, ſeemed to refract ſome of the priſmatic colours; from whence I was more ſurprized to have found no changes take place with the precipitants appropriated for the diſcovery of iron in water: when more than half of it was waſted, the dirty whitiſh pellicle was precipitated to the bottom of the veſſel, and a ſoft, unctuous ſubſtance floated on the ſurface of the water, which gradually diſappearing, a dark-coloured matter appeared precipitating in the remainder of the water, till, on compleating the evaporation, a ſoft black powder remained in the bottom of an earthen glazed veſſel, near thirty grains in quantity, exactly reſembling in colour and ſmell the boue in the baths; though the latter was much leſs ſenſible than in the boue, and the taſte of it was nearly the ſame, but leſs pungent on the tongue.

The appearance of this dark-coloured ſubſtance in the reſiduum was the more ſurpriſing to me at the time, as I had juſt been reading an hiſtorical and analytical eſſay, publiſhed by Mr. Deſmilleville, a phyſician of fame and character, on the waters and boue of St. Amand; in which he relates, that in the month of May, 1767, he had made, with the aſſiſtance of an able chemiſt, a Mr. Decroix, of Lille, an exact analyſis and critical enquiry into the nature and ſolid contents of both the waters and boue.

On the ſuppoſition that theſe gentlemen had really made a proper evaporation of theſe waters, for in one of their twenty experiments, they relate, that on the evaporation of ſix pounds of the water of the fountain of Arras, the ſtrongeſt and moſt impregnated with contents of the two (in the courſe of which they obſerved the pellicle that was formed on the ſurface of the water to be unctuous by the touch) and that when it was evaporated to dryneſs they diſcovered only 24 grains of a neutral ſalt, but do not ſay of what kind; it muſt appear ſomething extraordinary, that they ſhould not take the leaſt notice of ſo ſingular an appearance: and the greateſt part of the liſt of their experiments (an account of which Mr. Deſmilleville and Mr. Trecourt have publiſhed) are employed in ſhewing the effects of the waters in the diſcoloration of metallic ſubſtances, and other trifling proceſſes, to prove the exiſtence of a real hepar ſulphuris in theſe waters, and which in reality they did not, and could not find, by the methods purſued, if any others would have proved more ſucceſsful; and the diſcovery of an hepatic gas has been eſtabliſhed ſince that time, and could not be well known to them.

Such an appearance as I have related, (and which confirms the opinion they wiſhed to know, that the boue in the baths is in great part, if not altogether, a real depoſit from the waters) would have been of the utmoſt importance in ſilencing the unfavourable reports which had been propagated by an anonymous author, who had attacked the reputation of the waters of St. Amand in their moſt ſenſible part, as deriving all their ſulphureous taſte and ſmell from a filthy ſtinking moraſs in the middle of a large meadow, and from whence he has ſaid all their putrid vapours were derived; that their fame and character was entirely unmerited; and that the reports propagated of the extraordinary cures effected by theſe waters were without foundation, notorious falſhoods, and a groſs impoſition on mankind.

This unknown writer, againſt whoſe malicious aſperſions Mr. Deſmilleville's book was written, and the plan of his analyſis primarily undertaken, had aſſerted that the moſt ſcrupulous and exact experiments had never yet diſcovered an atom of ſulphur in theſe waters: the reality of which is very feebly ſupported by Mr. Deſmilleville; and on burning only a part of this reſiduum on heated iron, the ſulphureous vapours and flame which it exhales would have more effectually eſtabliſhed the reality of it in the water, than five hundred ſuch experiments as he has related.

Mr. Deſmilleville ſeems to have taken no notice of another circumſtance, of great import in his defence of the reputation and character of theſe fountains and boue, which would have afforded him a mode of accounting for the bituminous and ſulphureous ſubſtances, and which he could be no ſtranger to; and given him ample ground from whence he might have obviated all the ſuſpicions of the neighbouring moraſſes contributing in any degree to the formation of his favourite fountains and baths; this is the great abundance of pit-coal in all the ſurrounding country: and had he attempted the analyſis of his boue by diſtillation, he might have learned from Mr. Venel, how far the analyſis of it, expoſed to a ſtrong fire in a reverberatory furnace, will reſemble the analyſis of the charbon de terre, by experiment.—Vide his Treatiſe ſur la Houille.—And from the regiſter of the Academie Royale des Sciences we are informed, that, from the experiments of Mr. Morand le fils, Mr. Vauconſon, Laſſone, and Le Roi, November 25, 1769, certify, that the vapours from charbon de terre in burning are bituminous, and not ſtrictly ſulphureous, as generally ſuppoſed: and this certificate from the Academy of Sciences was obtained to certify, that the uſage of foſſil coal for culinary purpoſes, and warming rooms, was not attended with any injurious conſequences to the health of mankind, where the grates and flues from the chimneys are properly conducted.

We have before ſeen, in the waters of Spa, that under evaporation, as well as by ſtanding in the open air for any length of time, as ſoon as the priſmatic colours diſappeared in the pellicle, it broke into pieces and ſubſided; that the waters then loſt all their lively and briſk taſte, and would ſhew no changes or alterations with the precipitants; that the volatility of the hepatic gas, either in the open air, or under ſmall degrees of heat, ſoon deprived the waters of Aix-la-Chappelle of their ſmart pungent taſte, as well as of their diſagreeable odour and flavour;

and that the reſidua of theſe laſt waters appeared of a white ſhining colour, in no ſhape of a dark brown and even black colour, like the reſidua of thoſe at St. Amand.—It muſt reaſonably be expected, (for want of the whole of our apparatus to render it compleat, in order to form an accurate analyſis of the boue and the reſidua on the ſpot) that however carefully the boue might be packed, or the reſidua preſerved in bottles cloſely ſtopped, the volatile parts of them, ſuch as the aſphaltic and hepatic airs, would in part, if not altogether eſcape, in being carried ſix or ſeven hundred miles, through Paris and back to London, and kept there ſome months before proper leiſure could be found, and every other neceſſary provided to examine into them here. And that this was really the caſe, the ſubſequent experiments evidently evince. From this decompoſition of the ſubſtances, vain and uncertain muſt be every attempt to eſtimate and aſcertain with accuracy the proportional quantities of the different ſubſtances found in both the boue and the reſidua; and therefore, to avoid any miſtake and every wrong information in this part of the analyſis, no table is formed of the quantities of the different component parts.

When all theſe ſeveral ſubſtances depoſited from the waters were treated with a dilute vitriolic acid, a conſiderable effervefcence took place, and much fixed air was diſengaged.—On boiling different quantities of the boue with the fixed vegetable alkali, no appearance of a hepar was to be traced on an examination of the alkali.

No ſulphur was ſublimed from the boue when heated with a gentle heat.

When put on hot irons, it gave no blue flame, nor exhaled any ſulphureous vapour.

The nitrous acid ſeparated no ſulphur from the maſs.

When acids, particularly the marine, are poured in large quantities on the boue, it exhales an hepatic vapour.

Eight parts of diſtilled water being boiled for ſome time with one of the boue, and then filtrated, gave the following appearances on examination:

A quantity of lime-water added to the diſtilled water, after boiling with the boue, produced no precipitation, and effected no apparent change.

No change appeared from ſalited lime.

Nitrated ſilver, added drop by drop, produced no white curdly precipitate.

Nor was that effect produced on the addition of a ſolution of mercury made without heat in the nitrous acid.

The acid of ſugar gave an immediate appearance of white denſe ſtriæ, when the ſmalleſt portion was added; on a ſufficient quantity being employed, a copious precipitate of ſaccharated lime was, after ſome time, procured.

Salited terra ponderoſa gave a copious precipitate of baro-ſelenite.

On evaporating the water, no ſaline pellicles, or tendency to form regular chryſtals, appeared; but a white powder was thrown down, which was found to be gypſum.

A larger quantity of water took up

the whole of the gypſum belonging to the mud that was examined.

Another part of the boue, on which a proper quantity of water had been boiled, was expoſed to the action of diſtilled vinegar, as long as the acid would take up any thing.

The diſtilled vinegar, thus charged, gave the following appearances with the precipitants:

The tincture of galls threw down a conſiderable blackiſh brown ſediment.

The Pruſſian alkali gave a copious precipitation of Pruſſian blue.

Saccharated lime was thrown down in abundance on the addition of the acid of ſugar.

Aerated fixed vegetable alkali threw down a white precipitate; which with vitriolic acid formed a white and difficultly ſoluble powder, which was gypſum; and a bitter ſoluble ſalt, which appeared to be a magneſia vitriolated, or Epſom ſalt.

Marine acid, digeſted with the remainder, after the operation of the diſtilled water and vinegar, left an inſoluble reſiduum, which was ſiliceous, and was found alſo to have taken up argillaceous earth.

The groſs component parts being thus detected, the examination was not carried any farther.

By the preceding trials and experiments, the following principles manifeſtly appeared to be contained, though, for reaſons before given, the proportional quantities of each are not attempted to be ſtrictly aſcertained in the boue and reſidua of theſe waters.

Aerated lime.

Aerated magneſia.

Aerated iron.
Calx vitriolata, or ſelenite.
Argillaceous and ſiliceous earths.

THE aerated magneſia occurring again in theſe waters, and having before been found in ſo large a proportion in the Pouhon water at Spa, it may not be improper, before the cloſe of theſe examinations, to make a few curſory obſervations on magneſian earths, in order the better to underſtand the nature of them, as well as to clear up the confuſion that appears in ſome of the beſt writers on mineral waters in general, through their want of preciſion in diſtinguiſhing the different abſorbent earths.

Liſter, *Short*, *Rutty*, and many other more modern ſyſtematic authors, talk of a calcarious Glauber's ſalt exiſting in many mineral waters; with as much propriety as they might call ſelenite a gypſeous Glauber's ſalt.

And this is one inſtance of the number of imaginary different ſubſtances that have been introduced into the analyſis of mineral waters, by new combinations, merely through the impropriety of the terms by which they are denominated, and making ſuch a variety of abſurd diſtinctions where the proceſſes of nature, if properly attended to and underſtood, will appear the moſt ſimple.

The general effects of magneſia, when aerated, have been already attended to in the Introduction; and moſt of the above writers having no other knowledge of this earth than its effervefcence with acids, it is no wonder that they deemed it to be a calcarious one, and thought no other criterions neceſſary to diſtinguiſh it from lime. Hoffman had informed them, that crabs-eyes, prepared oyſter and egg ſhells, ſaturated with the vitriolic acid, gave out a ſubſtance that was almoſt devoid of taſte; whereas the magneſia earth, united with the ſame acid, yielded a bitter purging ſalt, ſuch as exiſts in Epſom water.

Dr. Black, and Margraaff, have demonſtrated, that the nature of magneſian earths holds forth conſtant and diſtinct properties, by which they may be diſtinguiſhed from lime and common calcarious bodies.

The foregoing authors have alſo formed another claſs of mineral waters, and which they ſuppoſe to contain a calcarious Glauber's ſalt, united with a portion of ſea-ſalt; and inform us alſo, that this combined ſalt will not readily chryſtallize, unleſs under ſudden changes from great degrees of heat to equal degrees of cold; and that it becomes deliqueſcent in the common atmoſpherical air: whereas ſuch combinations ariſe from ſalited magneſia, or the magneſian earth combined with the marine acid; and ſuch an union conſtitutes a great portion of the ſolid contents of ſea-water, and forms what is commonly called the bittern in ſea-water.

Magneſian earth is a diſtinct ſubſtance from lime, terra ponderoſa, argillaceous and ſiliceous earths, commonly called clay, and flint: ſhould all theſe different earths be reduced into the fineſt powder, and rubbed together with diſtilled water, they will not afterwards be ſeparable from one another but by their proper ſolvents; but he would depart greatly from truth, who ſhould from thence deny that magneſia, or any of the other earths, diſſolved or ſuſpended in the water, did not really and diſtinctly exiſt in it; and from thence conclude that the different varieties of them were produced by the different ſaline bodies with which they may be united. This earth exiſts in Spa, Pyrmont, and Seltzer water, in the very ſame ſtate as we have it from the ſhops, and generally prepared by precipitation with an alkali from Epſom ſalts, and deſtitute of every acid except the aerial one.

Marine ſalt is formed by the union of the marine acid with the mineral foſſil alkali, called natron alſo; but natron, combined with the vitriolic acid, makes Glauber's ſalt; and this laſt acid, by its union with clay or argillaceous earth, makes alum; the ſame combined with lime, or calcarious earth, forms ſelenite. The magneſian earth, laſtly, combined with the vitriolic acid, forms the bitter purging ſalt called Epſom ſalt; and which exiſts alſo in the ſame form in Seidlitz, Seidſchutz, Jeſſop, and many other waters.

It were much to be wiſhed, that, in all our inquiries after phyſical knowledge, and the inveſtigation of truth, when deep reſearches into the nature of the component parts, and well-conducted experiments, have repeatedly aſcertained the properties and diſtinguiſhing characteriſtics of any natural combinations, the application of any other looſe and vague terms, to ſuch complex ideas, may be avoided as much as poſſible.

The generation and reciprocal tranſmutations of bodies, are inquiries of ſo ſubtle and intricate a nature, that nothing certain ſhould be affirmed of the ſimple parts, by bare ſimilitude only, or a few unconnected experiments upon parts only of the compound: the firm agreement of both analyſis and ſyntheſis are abſolutely neceſſary finally to eſtabliſh the preciſe ideas of the component parts, as well as of their mode of union; and when once ſolidly fixed, the application of other terms, through the abuſe of words, expreſſive of any difference in their eſſential properties, would be deſtructive of its excellence, as well as put an end to all certainty in natural knowledge.

There are many different ways of preparing magneſia; the beſt and pureſt is procured by precipitation from Epſom ſalt, with a large quantity of alkali: the laſt lixivia of nitre and of common ſalt, and which will not chryſtalliſe, contain magneſia diſſolved in nitrous or marine acid; and the magneſia may be collected from them by precipitation, evaporation to dryneſs, and a ſubſequent calcination: but the magneſia that is thus obtained by calcination is not equal to that which is prepared by precipitation from Epſom ſalt; the former, if obtained from the lixivium of nitre, is adulterated with lime; and the common ſalt will always leave ſome marine acid, not to be ſeparated from the magneſia; the force of the fire alſo will diſſipate ſome of the fixed parts of the magneſia, and therefore leave a greater proportional part of the marine acid. When magneſia is prepared from Epſom ſalt by precipitation, it may be rendered ſtill purer by calcination, to free it from water and aerial acid; uncalcined, it occaſions in ſome habits uneaſy ſenſations in the firſt paſſages, by giving out its aerial acid; and calcination increaſes its purgative effects. Magneſia forms with the acids the ſame middle ſalts; it does not grow ſenſibly warm with water, nor diſſolve in it, like lime; and, from all the experiments hitherto made upon it, it appears to be a genuine pure earth.

Its medicinal powers are too well known to require any attention here; and it is alſo ſufficiently underſtood, that, as a purgative, it is uncertain in its effects, from its union with acids.

MEDICAL REFLECTIONS.

AN experienced phyſician may, from the foregoing examination, imperfect as it is, of theſe waters and baths, be induced to think (on a conſideration of the form of theſe boues, and the compoſition of the materials, actuated with aſphaltic and ſulphureous airs, when they are impregnated with proper degrees of heat) that a uſeful application, in a variety of ſhapes, as well as a good internal medicine, is held forth in them, in a variety of diſeaſes, as well as external corporeal affections, from wounds, accidents, and contuſions, as through debility and contractions of the limbs; and that it is of high import to the public, as well as to every perſon who may be intereſted in the reputation and ſucceſs of the boue baths in particular, of St. Amand; eſpecially the latter, to attend to every poſſible improvement, for a more elegant as well as a more convenient and efficacious mode of their application, if they wiſh to improve their property, and maintain the fame and credit of their baths.

Though I do not profeſs to believe all the marvellous relations of their extraordinary efficacy, in a variety of caſes that are here recorded, and circulated by various authors that have written upon them; yet I am ſo far an advocate in their ſupport, as to think that ſuch cures may be here ſometimes effected, by a variety in the modes of their application, when judicioufly directed, and the many methods of uſing both the waters and baths have obtained all the improvements they are really capable of acquiring, as could not be accompliſhed, if at all, in ſo ſpeedy and compleat a manner, by any other of the waters and baths at preſent known in theſe parts of the world.

The general ſtate of medicine, as a ſcience, till towards the middle of the laſt century, was founded on the principles of the ſyſtem originally taught by Galen: and though Paracelſus, and other romantic authors, had introduced many chemical preparations into medical practice, yet the ſyſtem itſelf ſtill continued to be ſupported and maintained, by referring all the different appearances, both of health and diſeaſe, to the ſtate of the fluids only.

The diſcovery of the circulation of the blood, happening about that time, drew the attention of the more learned profeſſors to the conſideration of an organic ſyſtem exiſting in all animal bodies; this knowledge led them to the application of mechanics, in the explanation of many parts of the animal œconomy; but many defects aroſe from their being little able to carry this branch of natural philoſophy to any great extent, or explain all the parts of it in a ſatisfactory manner: and though chemiſtry began at this time, or very ſoon afterwards, to promiſe greater reſources in the explanation of many phænomena in the hiſtory of diſeaſes, yet the humoral pathology ſtill continued to compoſe the great bulk of every ſyſtem of phyſic.

It had been obſerved, from very ancient times, that every animal body contained in itſelf a power or ability of reſiſting injuries that were offered to it from without, by which alſo it could frequently relieve itſelf, and remove diſeaſes that were introduced into it; this was attributed to ſome agent in the ſyſtem of the animal body, and which was called nature; and which, under the term *vis conſervatrix*, or *medicatrix*, has maintained its ground till the preſent times.

Stahl placed this power in the rational ſoul, which acted independently of the body, and, from its knowledge of the offending cauſes, would excite certain motions in the animal fibres, to obviate their ill effects, and by theſe means get rid of all the conſequences from the injury that had been offered to the ſyſtem.

Hoffman changed the medico-organic power of Stahl, ſeated in the ſoul, into a medico-mechanical power of nature: both which ſyſtems, in the hands of all the learned men who embraced theſe doctrines, produced a very feeble and defective mode of practice, leaving more to be hoped for from the powers of nature than the events of the diſeaſes could juſtify; which ſuperſeded all the attempts of art, and led to an abſolute rejection of ſome of the moſt powerful remedies, ſuch as are opium and the Peruvian bark; a ſyſtem which ought never to be generally admitted, but where the inability of art to give relief is manifeſtly ſtriking, and has been confirmed by reiterated, though vain, attempts of cure.

It muſt however be confeſſed, that,

from various parts of his works, it manifeſtly appears, that Hoffman himſelf was not perfectly ſatisfied with the doctrine: he was ever eager to adopt new ſyſtems, through the warmth of a ſanguine temperament; yet, as he had a clear head, and a good heart, he ſoon perceived great defects in it; and, by new modifications of the opinions of his predeceſſors, as well as his own doctrines, he abſolutely gave riſe to the great improvements that have been ſince made in the more ſucceſsful methods of practice, by the introduction of ſpaſm, or ſimple atony; and brought forward a new pathology, in which the ſymptoms of many diſeaſes are deduced from diſturbed motions of the ſolids, more evidently than they can be from any vitiated diſpoſition of the fluids; and which he refers, in many parts of his writings, to preternatural affections of the nerves and the nervous ſyſtem.

Infinite are the obligations which phyſicians owe to Hoffman, for leading them into this train of inveſtigation; and there is ſtill great reaſon to believe, that there remains much room to carry our inquiries ſtill farther than they have already been, before we ſhall attain to the moſt perfect mode of practice: the ſubject is attended with infinite difficulties, for the laws of the nervous ſyſtem, in many circumſtances of the animal œconomy, are by no means hitherto aſcertained: we muſt not be ſurprized that Hoffman, blinded as he ſtill was with the abſurdities of the humoral pathology, made no further progreſs in a ſubject almoſt inexplicable, when

Boerhaave, a man of greater abilities, and univerſal erudition, left the ſyſtem loaded with great imperfections and deficiencies, inſomuch that a new one, and a better, if poſſible, ſtill appears neceſſary.

It will not be required on this occaſion to point out the defects of Boerhaave's ſyſtem, though juſtly founded on the rigidity or laxity of the ſimple ſolids primarily; but the danger of his ſyſtem ſeems to ariſe from ſuch miſtakes as may lead us into erroneous practice. His inattention to the changes that may happen in the living ſolid, changes that ſeldom take place in the ſimple fibre, conſidered only with regard to its original laxity or rigidity, may be one and a great cauſe of frequent errors. His ſuppoſition of an acrimony or lentor exiſting in the ſtate and condition of the animal fluids, may be another ſource of great miſtake; and this opinion ſeems evidently a part of an hypothetical humoral pathology.—Another misfortune, attending every modification of the humoral ſyſtem, ariſes from the diverſion it occaſions of our attention from the various motions exiſting in the animal ſyſtem, upon which the phœnomena of diſeaſes moſt certainly and moſt generally depend: and Boerhaave's acid and alkaline acrimony of the fluids is not only hypothetical and unſupported by fact, but is inconſiſtent with other general doctrines he has advanced, and juſtly, of the general nature of the animal fluids.

The uſe that is intended to be made of the preceding ſhort narrative of the general ſyſtems of medicine, as a ſcience, prevailing in the world in different ages—and which have governed and directed the practice of all the phyſicians who lived in thoſe different times—is the application of theſe different ſyſtems to the medicinal uſes of different mineral waters, and to the different views that phyſicians muſt have had, under the influence of ſuch different doctrines, in ſelecting the choice of the different mineral waters, and recommending any particular ones to their patients; which application is intended to be made excluſive of the facts collected from experience, and delivered to the world in the different hiſtories and publications of caſes which have received benefit from the uſe of theſe ſeveral different mineral waters.

The diſciples of Galen, and the patrons of plethora and cacochymy of the fluids being the only cauſes of diſeaſe, muſt direct their attention principally to mineral waters abounding with abſorbent and alterative earths, joined to purgative ſalts: and the diſciples and ſucceſſors of Stahl, if any ſtill remain in Germany, ſeem to have been actuated by ſuch motives, chiefly, in directing their patients to take all mineral waters in exceſſive large quantities; hence, whenever a German is ſent to any mineral water, of whatever nature it may be, he will be ſure to drink three times the quantity that the people from any other country do.

The admirers of Hoffman, who, under every modification of his doctrines, ſtill continued a humoral pathologiſt, will put great confidence in the alterative principles of every mineral water: while others, who are ſtruck with his doctrines of ſpaſm, will ſearch for ſedative qualities in the waters, in which they can place the greateſt degrees of confidence.

The ſchool of Boerhaave will ſearch for cold and warm baths to relieve the diſeaſes ariſing from the lax or rigid fibres of their patients; and happy would it be for them if their phyſicians were equally inſtructed in thoſe changes which may more abundantly affect the living fibre: it is equally to be hoped, that practical experience has taught them to look upon acid or alkaline acrimony as imaginary cauſes of different claſſes of diſeaſes.—And the diſciples of every other ſchool of medicine, in theſe more enlightened and better inſtructed times, will diligently attend to the effects of mineral waters on the different animal motions, without ſpeculating on thoſe fanciful hypotheſes, which have ever been found prejudicial to the cauſe of real ſcience in general, but, when applied to the ſtudy of medicine in particular, can hardly fail of being attended with conſequences ſtill more ſerious and full of danger.

The myſterious parts of medicine, when conſidered as a ſcience, if there is any myſtery in the art of healing, (and the leſs there is the better) independent of real knowledge and ſcience, aided and aſſiſted by experience, and a faithful and conſtant attention to the riſe and progreſs of diſeaſe—have been ſo long involved, and through ſo many ages, under thick clouds and darkneſs, from a ſuppoſed variety in the different kinds of acrimony exiſting in the humours and fluids; and the art itſelf has been ſo long encumbered with a confuſed farrago of uſeleſs compoſitions, called medicines, calculated, as is ſuppoſed, to correct ſuch imaginary ſharpneſſes in the blood and humours; that a true phyſician will think it his duty attentively to conſider what are the real powers of nature, in the relief of the melancholy liſt of diſeaſes to which the human frame is either liable, or expoſed, from intemperance and impropriety of conduct; and he will ſoon find, when put into a proper track to inveſtigate them, that theſe powers are derived, as well as the diſeaſes themſelves, from a very different part of the animal ſyſtem; and, beſides what information he may obtain from the beſt writers on the *ſolidum vivum*, and the doctrines of irritability now taught in the beſt ſchools of medicine, he will think it the principal part of his profeſſion to underſtand, and comprehend fully, all the cauſes and effects of animal motions, as far as the knowledge of them can be obtained by human ſagacity.

FINIS.

POSTSCRIPT.

THE Author of theſe Eſſays purpoſes to have them tranſlated into French, under his own inſpection, next winter; to which will be added, ſuch further information as he may obtain on a ſecond viſit to the ſame fountains, this preſent ſeaſon: and ſuch additions, ſhould any occur worthy of notice, will be printed alſo in Engliſh, next winter, for the accommodation of the purchaſers of the preſent Treatiſes.

London,
July 1ſt, 1788.

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